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INSTRUMENTS

THE MAGAZINE OF MEASUREMENT AND CONTROL

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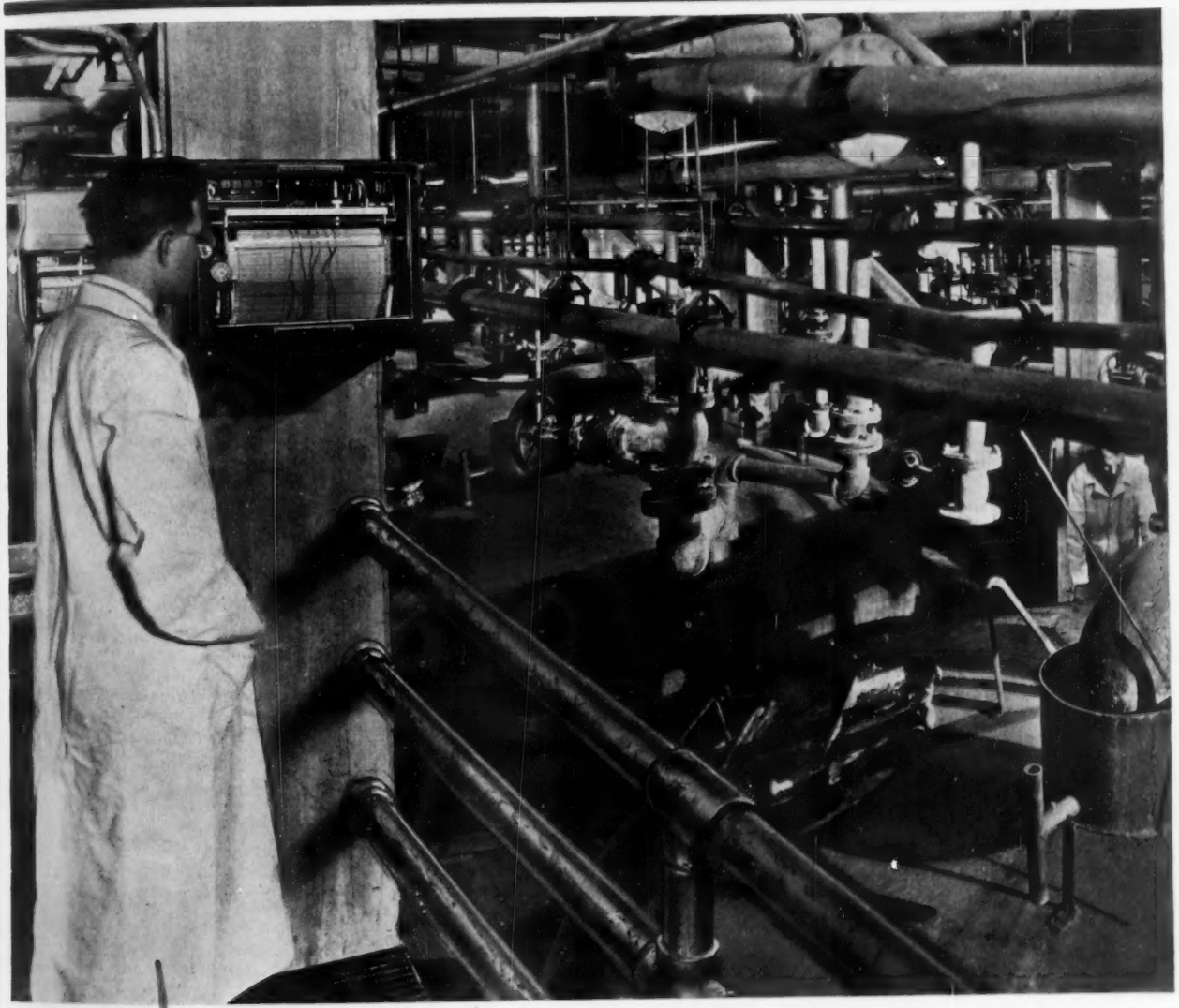

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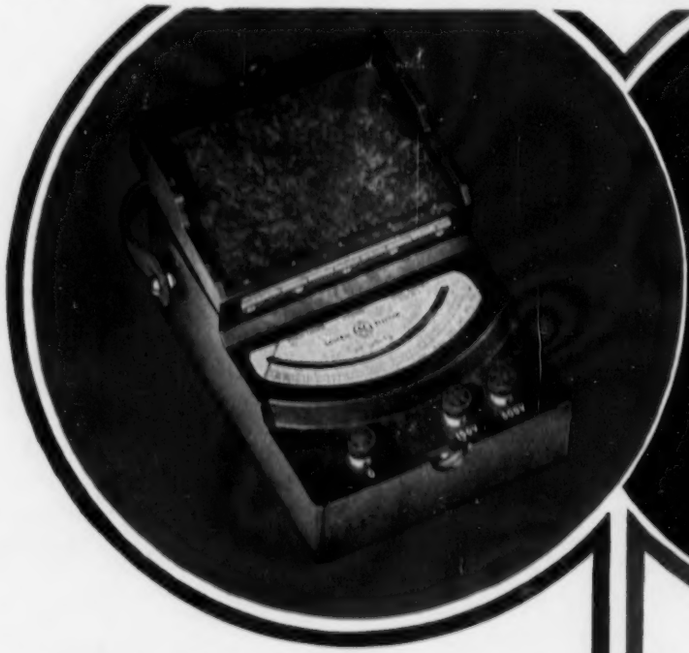

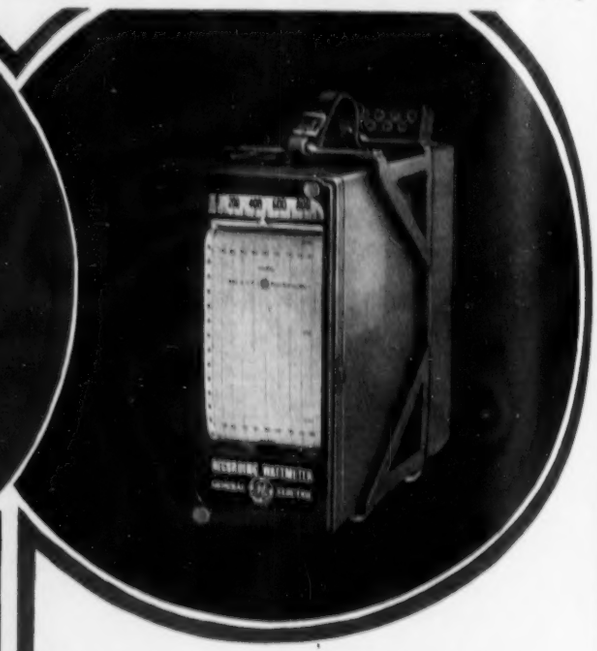

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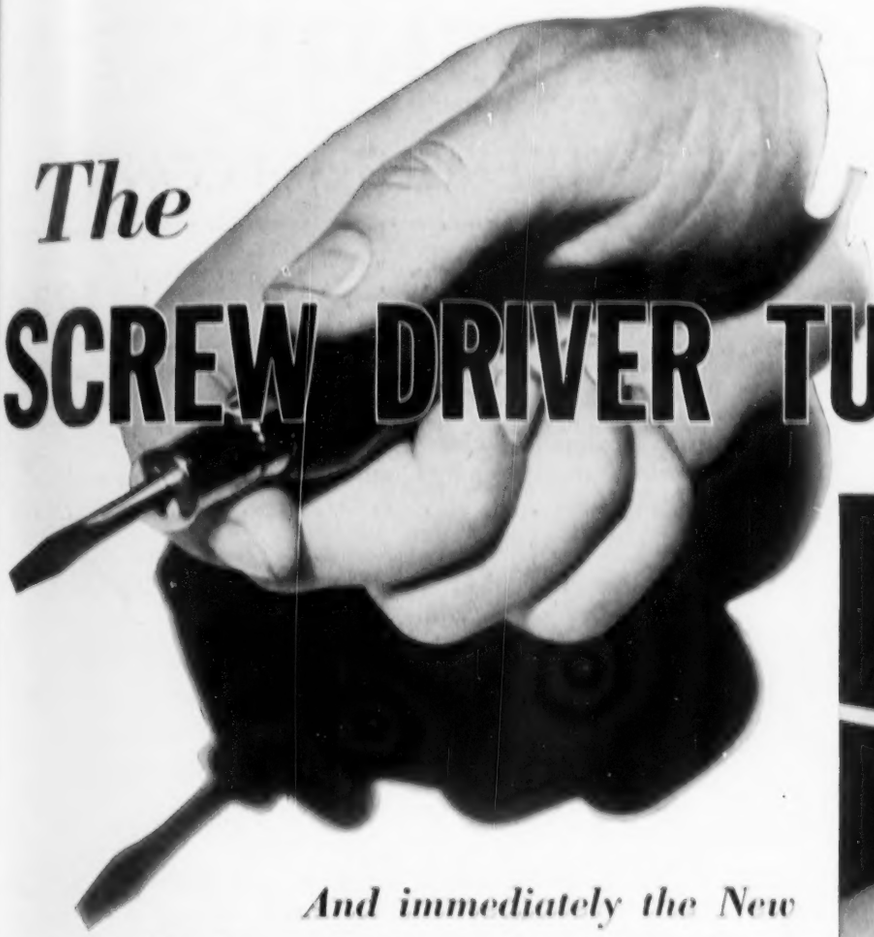

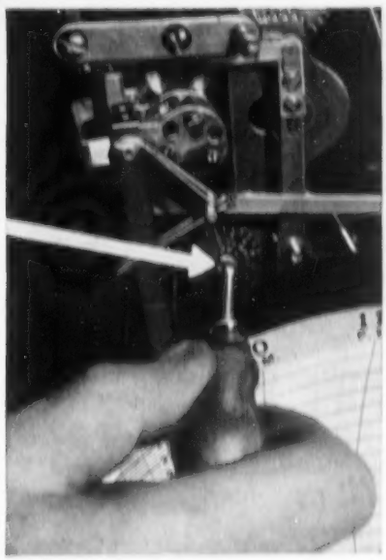

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INSTRUMENTS

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EDITORIAL COMMENT

In This Issue

The first article ends with a negation which we consider a challenge. On first reading the manuscript as it was submitted, we paused at this last sentence, considering whether to strike out Mr. Thompson's flat statement that the sequencing control he describes can be applied profitably in only two fields. To be sure these are two important fields, but aren't there others?

The use of a synchronous motor for timing oscillograms dates back to around 1898 when some European workers attached a circular rheostat to the shaft and got a zig-zag pattern; but now Messrs. Sundt and Fett describe their latest wrinkle and the beautiful results it gives, which seems superior to the latest European practice of a synchronous-motor-driven sectored disk rotating in front of a photocell.

Don't send a rush order to Mr. Hamblen and Dr. Kay for a miles-per-gallon indicator for your car: You're not the only one who wants one for his private use, but their ingenious device is not yet on the market—if it were commercially available, it would be described in the "New Instruments" Section, not in a feature article. Rules is rules!

Although the *results* of the tests Mr. Tulus describes concern a limited group of men, nearly all readers will find his *means* of distinct interest in connection with all studies of vibrations and related subjects.

Two more classes of electrical instruments—for synchronism and for frequency—are dealt with in this month's instalment of the Electrical Measurement and Control series.

This month's crop of New Instruments has an unusually large proportion of testing devices. Since demand governs supply, we infer that purchasers of materials, grown instrument-conscious, are stimulating the development of new testing methods and means. Is this an effect of the New Deal?

The Front Cover

Instrumentation progressed more during Prohibition than during any previous thirteen-year period. No, it wasn't cause and effect! Anyway, the liquor industry on re-awakening found useful processing aids it had never known, and is adopting them: At the Continental plant, six Brown 12-record resistance thermometers (with their 72 bulbs in 54 fermentation tanks, 12 yeast tubs and 6 cookers) play a major part in the making of better whiskey than gran'pa ever tasted.

Instrumentation Terms

ONE of the things we like to do is to discuss instruments with instrument men. So do you. And we bet the kind of powwow that doesn't break up until past midnight is the one where you and your brother instrumenticians discuss automatic controllers, where quires of paper get filled with control system hook-ups and formulas, and where friendly but impassioned arguments rage . . .

Haven't you noticed that whenever a newcomer makes his appearance in your circle—from another branch of instrument work, from another profession or from another company—you have a hard time understanding him, and he you?

It's nobody's fault—and everybody's: in the field of automatic control several languages, all made up of English words, are being used. You can verify this by comparing articles on control technology in different journals, or by listening to the sales engineers from different companies who call on you, or by attending a meeting where several papers are read dealing in whole or in part with control.

Here are some of the terms that undergo changes of meaning:

Impulse, indication, quantity, factor, magnitude, condition, value, performance, deviation, departure, functioning, lag, steamline flow, setting, setting point, position (as adjective), adjustment, readjustment, floating, proportioning, modulating, demand, supply, capacity, rating, rate, characteristic, characteristic curve, follow-up, interrupter, range, rangeability, calibrate, normal, standard, scale, zone, region, point, transform, transfer, translate, transmit, reaction, resistance, response, measuring, metering, determining, relay, pilot, medium, flexibility, sensitivity, anticipatory, anticipating, as well as "automatic," "semi-automatic," "controller," "regulator," "—stat," "governor," etc., and those long-abused words, *accuracy* and *precision*.

When one Pittsburgh manufacturer of automatic control systems hired a designer of such systems from another firm in the same line, he and his new associates couldn't understand one another. Reason: he had worked on electrical systems, his new employers specialize in fluid-relay systems.

Back of it all is the fact that automatic control practice is so far ahead of theory that throughout all these years of ingenious developments the principal terms and basic general principles of "instrument control" technology had not been formulated, and never appeared in print until two years ago. And the text in question is only a meager beginning.

There seems to be a need for something to be done about it. No group of men is better qualified than are the readers of *Instruments*.

M. F. Behar

A Friendly Circle

MORE and more as the years roll by—some prosperous and some lean—the men who make *Instruments* derive a satisfaction that no money could buy from the ever-increasing evidences of friendliness on the part of subscribers. The chances are four out of five that you who read this have added a complimentary paragraph at the end of a request for information, a change-of-address notice or whatever kind of letter you had occasion to write. We thank you, and you and you! From time to time we print some of your letters—not out of vanity but to let you know that the friendship you honor us with is keenly appreciated. We particularly thank the subscribers who send in group subscriptions: five, seven or ten at a time; and for Walter E. Smith of Honolulu who recently brought in twenty-two new subscribers (see page 176), we simply can't find words of appreciation. He, by the way, set a new record, and he must have worked under difficulties by reason of the way the sugar plantations are scattered in the Hawaiian islands, so that we shouldn't be surprised to have *you*, in a concentrated industrial center, send in more than twenty-two.

Application of Automatic Sequencing to Load Control and Frequency Control in Power Stations and Systems

By L. N. THOMPSON*

DURING the last three or four years considerable experimenting and a great deal of discussion has taken place regarding automatic frequency and load control as applied to power stations and power systems. This article discusses some of the features of Load and Frequency Control in general, and in particular the automatic sequencing of turbine valve openings and closings with regard to the following four requirements:

A. Load control to facilitate the loading in the most economical order of the various units in a given station or system.

B. Load and frequency control to facilitate the interchange of power between power stations or power systems.

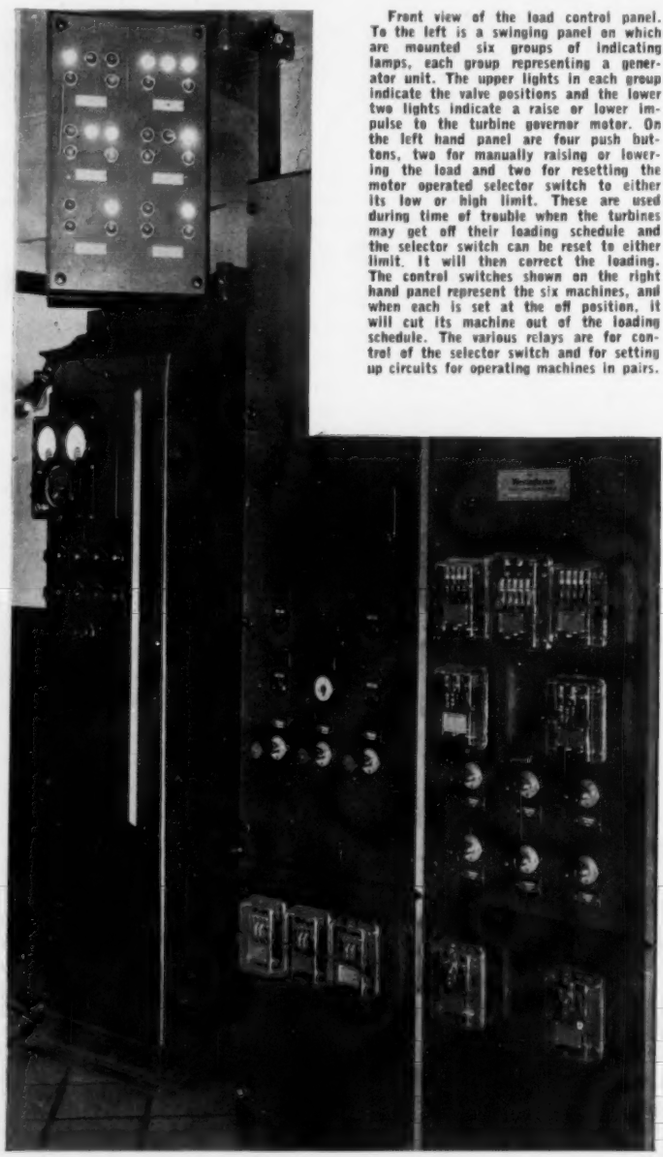
C. Constant frequency to obtain constant and uniform motor speed for such purposes as are required by the textile and paper industries.

D. Constant average frequency to operate electric clocks to keep correct time.

Load Control refers to proper order of loading the several units in a power station or system, to give a desired—usually a minimum overall—fuel consumption. Frequency Control is concerned with the regulation of the frequency of any station or system for any desired end.

Of the four requirements mentioned the most important is the proper sequence of loading the units in a given station or system, because it has to do with day in-day out operation of a station in the most economical manner. The various units in a station are usually of different design characteristics, different capacities and different efficiencies. Therefore, it might be most economical of fuel to carry the first load increment with a 60,000 kw. unit with the primary valve wide open; the next increment might best be carried on a 30,000 kw. unit with a primary valve and secondary valve wide open; perhaps the third increment would go again to the 60,000 kw. unit with the primary valve and secondary valve wide open, etc. Dropping of load is taken care of by closing of valves and taking machines off load in exactly the reverse order. (By load increment or drop is meant any change of load sufficiently large to be detected by the control equipment.)

Considerable study by members of the engineering staff of one large public utility company has been devoted to this problem of proper sequence in the loading of various units in order to obtain maximum economy in heat rate for the station or system. A system of loading was developed in which a new principle was used, namely, that of loading of any machine on any given valve up to the full capacity of that valve. That is, on a given machine, if a primary valve is opened at all it is opened all the way or nearly 100%, so that the throttling loss incident to partly opened valves is obviated. This full open valve procedure, of course, cannot be carried out rigorously since at least one valve must be partially open some of the time to enable the turbine to carry the exact amount of load demanded by the system, but one valve would usually be sufficient for this purpose.



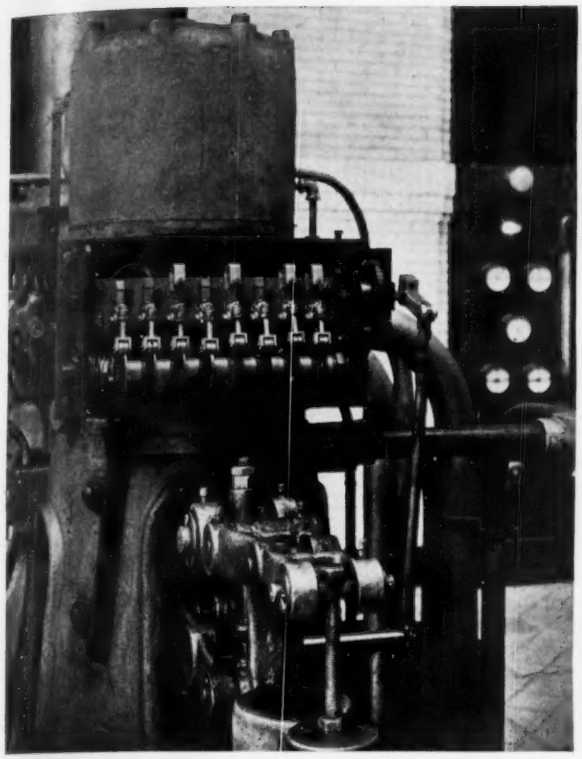
Front view of the load control panel. To the left is a swinging panel on which are mounted six groups of indicating lamps, each group representing a generator unit. The upper lights in each group indicate the valve positions and the lower two lights indicate a raise or lower impulse to the turbine governor motor. On the left hand panel are four push buttons, two for manually raising or lowering the load and two for resetting the motor operated selector switch to either its low or high limit. These are used during time of trouble when the turbines may get off their loading schedule and the selector switch can be reset to either limit. It will then correct the loading. The control switches shown on the right hand panel represent the six machines, and when each is set at the off position, it will cut its machine out of the loading schedule. The various relays are for control of the selector switch and for setting up circuits for operating machines in pairs.

In following a certain sequence of loading, then, it always is definitely known not only to which unit will be given the load change and in what order the units will be loaded, but also in what order the various primary, secondary and tertiary valves will be opened and closed. This necessarily involves quite a program of manipulation which, to say the least, would be inadvantageously carried out by manual control and it manifestly would be impractical to burden the switchboard operator with the responsibility of carrying out so extended a series of operations. This is especially true in times of emergency, such as severe electrical storms, or when short-circuits occur. So here are cases in which a system of load control fulfills a real need by performing these several operations automatically.

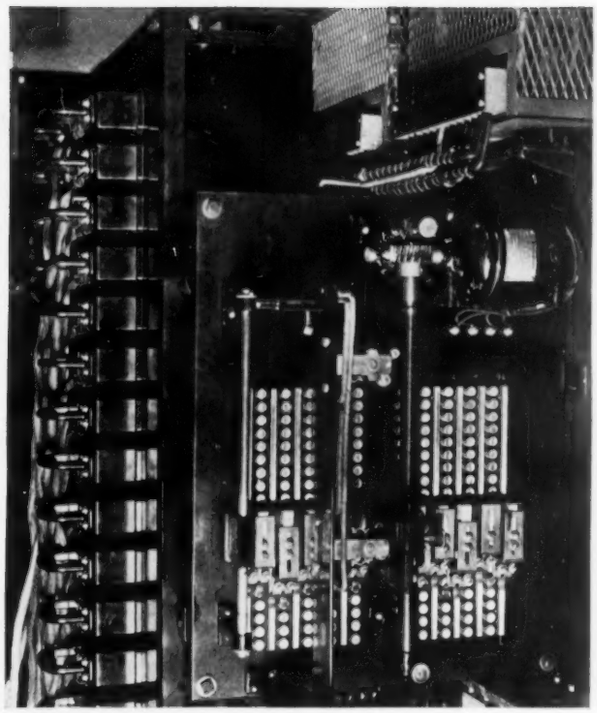
In making the carrying out of these loading operations automatic, we not only take away from the switchboard operators what is for them a more or less difficult task, but we make absolutely sure that the sequence of operations will always be rigorously carried out day in and day out.

The requirement of next importance, that of frequency and load control as relating to the interchange of power between stations or systems, is concerned principally

*Westinghouse Elec. & Mfg. Co., So. Phila. Works, Marine Apparatus Division. Formerly with Duquesne Light Co., Power Stations Dept.



In program loading, the division of load among units is determined by the valve positions on the steam turbine. This illustration shows the cam-operated switches with a mechanical linkage to the turbine valve gear. As the turbine valve opens with increasing load on the unit, the various contacts make or break circuits which control the position of the motor-operated selector switch. Note that the cam switch is so geared that the full movement of the turbine valve mechanism will produce one complete revolution of the cam shaft. This type of switch provides extremely accurate adjustment to make or break contacts at phase positions where the turbine valves just open or just close.



The motor-operated selector switch which routes the raise or lower impulses from the master controller to the various units according to a predetermined schedule. To the right are two rows of receptacles, one row representing machine valve ranges and the other row representing the sequence steps. By means of plugs and jumpers, the loading schedule is set up. For example, the rear receptacles represent sequence points from 1 to 16 reading from top down, No. 1 primary valve, No. 1 secondary valve, No. 1 tertiary valve, No. 2 primary valve, No. 2 secondary valve, etc. Thus, in making up the loading schedule, if it is desired to load No. 2 machine to full primary valve first, the third rear receptacle would be connected to the first front receptacle by means of the plugs and jumper. Now, if it is desired to load No. 1 machine primary to full primary on the second loading, the first rear receptacle would be connected to the second front receptacle by plugs and jumpers.

with loading and protection of tie lines, which are the transmission lines between stations or systems carrying the load being interchanged.

The functions of a tie line are to minimize investment during system development and to take care of emergency conditions. In order to minimize investment an additional capacity unit in a given station must be justified before it is installed. A given station might require only 30,000 kw. additional capacity while the station development program would call for an additional unit of 60,000 kw. capacity. It would surely be unwise to purchase a 60,000 kw. unit when only 30,000 kw. of capacity was required. By purchasing an additional 30,000 kw. of power from an adjacent system or receiving it from an adjacent station, the purchasing of the new 60,000 kw. unit might be deferred until such time as the full 60,000 kw. would be required.

The matter of emergency load conditions is of more immediate importance, however, than that of minimizing investment, as the ability of a system to take care of the emergency conditions is a direct measure, as regards continuity, of the quality of service maintained.

Tie lines between stations of a system are, of course, of sufficient capacity to carry the entire station capacity, while tie lines between systems are large enough to carry only a small per cent of the system capacity. This is as it should be, because station loads may and must be shifted from station to station in proper sequence to get most economical loading of the system, and tie lines must then be large enough to carry peak loads whenever and wherever they occur, while intersystem tie lines are called upon to carry only such interchange of loads as may be agreed upon, and that only during emergency or peak load conditions.

If it were expedient to have tie lines between systems large enough to exchange the entire peak capacity of the system from one system to another, then in all justice the excess capacity of each system should be great enough to carry the peak load capacity of any other. This would, of course, be an absurdly uneconomical investment, so tie lines between systems are built for small capacity compared to the system capacity. The usual service expected of a tie line is to carry the load corresponding to the loss of the largest machine in either system.

These conditions accentuate the difficulties of load and frequency control, because any sudden change in load cannot always be shifted from one system to another on account of the inability of the tie line to carry it, and the load control apparatus must function in such a way as to protect these tie lines from overload, or the circuit breakers from kicking out and cutting off the load entirely.

On the other hand it is not at all necessary, or even desirable, to shift great amounts of load from one system to another. For example, a change of load in Pittsburgh should not be picked up in Chicago but in Pittsburgh. In other words only such shifts of load should take place between systems as are absolutely necessary to take care of emergency load conditions and the load control system used should accomplish this result.

So much for load and frequency control combined. The other requirements mentioned, regarding load and frequency control, have to do with frequency control alone. The need for constant frequency, to facilitate constant motor speed for such industries as the paper mills and silk mills, requires no comment except that any variation in speed of silk mill machinery breaks threads, and that paper machines also require exact speeds.

The matter of keeping a frequency that will make possible the running of electric clocks to keep correct time is a matter of minor importance compared to the larger features of load and frequency control. However, this requires that an average frequency only be maintained, or that the total number of cycles in twenty-four hours should be constant, with momentary variations not exceeding about 30 seconds on the clock. Clocks run by synchronous motors should keep very good time on a system with this variation. For railroad work the variation should be considerably less.

As far as the economics of the situation is concerned there is no doubt, as stated before, that much is to be gained by the light and power companies in maintaining the most economical load on the several units of the several stations; and for concerns dealing in electric clocks there are possibilities of commercial development. Outside of these two fields, however, there do not seem to be many applications for realizing considerable "dividends" on an investment in automatic sequencing equipment.

A New Timing Method for the Cathode-ray Oscillograph

By E. V. SUNDT* and G. H. FETT*

USUAL methods of timing the cathode ray oscillograph involve the calibration of some decrement curve, or of some oscillator. A timing device which is simple, easily calibrated, accurate, and can be adapted to various requirements is highly desirable. Such a device is described. It was used successfully in obtaining time-current characteristics of instrument protection fuses and was experimentally used in obtaining time-current-voltage oscillograms of a neon glow lamp, an inductive circuit with a voltage suddenly applied, etc.

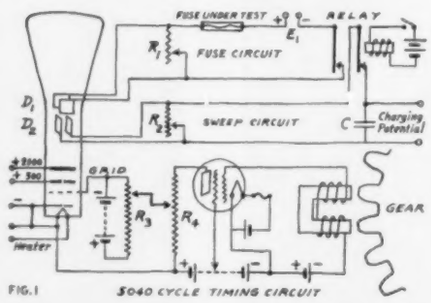


FIG. 1 5040 CYCLE TIMING CIRCUIT

A type 905 cathode-ray tube has a fluorescent screen, and a grid which controls the illumination on the screen. The scintillations of light produced by the electron beam striking the screen are of a brilliant green color, wave-length of 5000 angstroms. If an alternating potential is applied to the grid, with the grid biased correctly, the grid will alternately permit and stop the flow of electrons to the screen, exactly in time with the potential. If the beam is caused to deflect rapidly by any means (in this case a change of voltage on the deflecting plates), a dashed line will result, of known time interval of separation of the dots.[1]

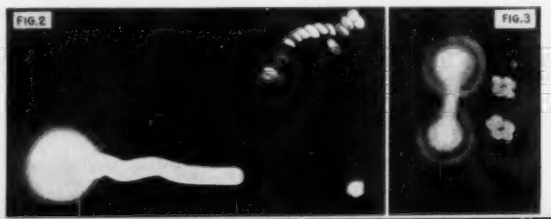


FIG. 2 FIG. 3

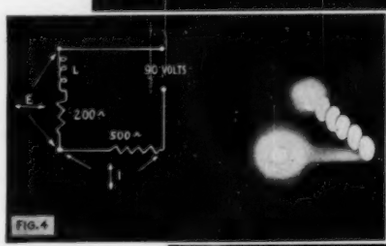


FIG. 4

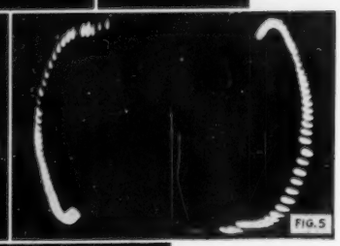


FIG. 5

FIG. 6

The source of high frequency was a generator made up of a small U-shaped magnet (a loud speaker unit) mounted close to an iron gear with a large number of teeth. Driving the gear with a 3600 r.p.m. synchronous motor operated from the 60 cycle power line insured accurate control of the frequency generated in the coils of the permanent magnet. This was amplified and placed on the grid of the cathode-ray tube. With the gear used, the frequency was 5040 cycles per second. Fig. 1 is a diagram of the circuit used to obtain time characteristics of fuses. The lower part of the diagram, of course, can be used for many other purposes.

To spread the beam when taking the time-current curves, the sweep circuit shown was used. It is not necessary that the sweep voltage vary linearly, or in a known manner, as the timing device takes care of the timing automatically. With 2000 volts on the anode, and 500 volts on the focusing anode, a small change of the grid voltage supplied by the drop across R_4 is sufficient to shut off the electron stream completely.

An interesting analogy can be made in comparing the time device with a machine gun shooting bullets at regular frequency. The spaces between the teeth of the gear permit the passage of the "electron bullets" beyond the grid, and after being accelerated by the potential of the anode, they splatter on the fluorescent screen, there to make themselves evident. When the teeth are in the next position the electron beam is cut off.

Fig. 2 is an oscillogram showing the operation of a ¼ ampere instrument fuse. The brilliant spot at the left is the beam at rest. When the relay circuit is closed, the sweep circuit pulls the beam across the screen by means of plates D_2. A short time later, the 250 volt fuse circuit is closed, and the fuse current is measured by R_1 and impressed on plates D_1. The time of operation was about 0.004 seconds, as there are 20 spots, each spot representing 0.0002 seconds. The wavy appearance at the top of the curve indicates that an arc has formed and would show that the fuse is operating close to its maximum permissible voltage. Note that the spots are sharp, providing a definite means of measuring time. For fuses in the range of 1/100 ampere, the time of operation is so short that only one spot is seen.

An interesting oscillogram is Fig. 3. In testing a 1/16 ampere fuse, the relay contacts in the fuse circuit bounced, so that the current was not constant. The first contact lasted 0.0008 sec. (4 "bullets"); the second 0.0010 sec. (5 "bullets") during which the fuse operated.

This timing method permits voltage, current, and time to be recorded simultaneously. Fig. 4 is an oscillogram of the voltage across, and the current through an inductance coil with a voltage suddenly applied. As evident from the horizontal trace (obviously <0.0002 sec.) the voltage at the instant the circuit closed reached its maximum, because the inductance coil acted as a momentary open circuit, while the current remained zero (trace is horizontal). Then, the current increased and the voltage dropped, until at the end of 1/1200 sec. steady state was reached. The latter, too, is blurred due to the large number of spots in the same place. (The *E-I* curve dots have been retouched on this oscillogram.)

It is interesting to note that a Lissajou pattern, such as that of Fig. 5 (that of a neon lamp current spread out by a potential out of phase with the lamp voltage) is remarkably steady over long periods of time. This oscillogram was taken with a half-second exposure, 30 repetitions, yet the picture is not blurred. The frequency was quite constant; the error lies only in the accuracy with which the spots can be distinguished.

Some interesting and beautiful patterns of recurring phenomena are obtained when using the above timing method. Fig. 6 is produced by applying 110 volts a.c. on plate D_1 and a few volts a.c. on D_2 90° out of phase to spread the pattern. The effect of harmonics is shown by the fact that the pattern is not a true ellipse.

After considerable experimentation, a *f* 1.9 lens and Wratten hypersensitive plates were used to obtain satisfactory results.

The authors wish to acknowledge their debt to Mr. T. Spackman and Mr. W. Gorrell for aid in photography, and to the Eastman Kodak Co. for advice on photographic plates.

*Littelfuse Laboratories, Chicago.

[1]After the completion of this work, the author's attention was called to the article, "Time-marking a Cathode Ray Oscillogram" by L. F. Richardson, *Proceedings of the Physical Society* (London), Vol. 45, 1933, page 135. This article describes a similar method, except that the beam focus is changed instead of blocking the beam. The advantage of using the grid is obvious, since the focus is not disturbed, and a low potential is handled, instead of the high voltage required on the focusing anode of the 905 tube.

A Thermal Type Miles-Per-Gallon Indicator

By J. B. HAMBLEN and W. B. KAY

AVERAGE rate of fuel consumption for an automotive vehicle is usually obtained by keeping a record of gasoline purchases and speedometer readings. This method is unreliable because it is influenced by driving conditions such as average speed, amount of idling, and length of trips. It is inconvenient to keep a complete record; and the length of time necessary to obtain even an average figure discourages most motorists. An instrument which will give a *continuous* indication of the *rate* of fuel consumption under known driving conditions will not only satisfy the motorist's desire to know how many miles he obtains per gallon of gasoline, but it will also indicate when adjustments become necessary, and when such adjustments have been made correctly.

Devices previously developed for indicating miles-per-gallon have proven impractical because they employed floats, measuring chambers, governors or other parts subject to failure to function properly on a moving vehicle. Difficulties arising from the use of such elements have been avoided in the present instrument* by eliminating moving parts and employing only electrical means. The instrument, shown diagramatically in Fig. 1, consists of a heating element located in the gasoline line, a small electrical generator, and a differential thermometer composed of a multiple thermocouple and millivoltmeter. The instrument operates by adding heat to the fuel entering the carburetor in proportion to the speed of the car, and measuring the resultant rise in temperature. Current to element is furnished by a generator driven by a rotating part of the car such as the speedometer drive. The generator, which has a steep voltage *vs.* speed characteristic curve, supplies heat to the flowing fluid in proportion to the miles per hour. The resultant temperature rise is therefore directly proportional to miles per hour and inversely proportional to gallons per hour. Obviously, if miles per hour be divided by gallons per hour the result is miles-per-gallon.

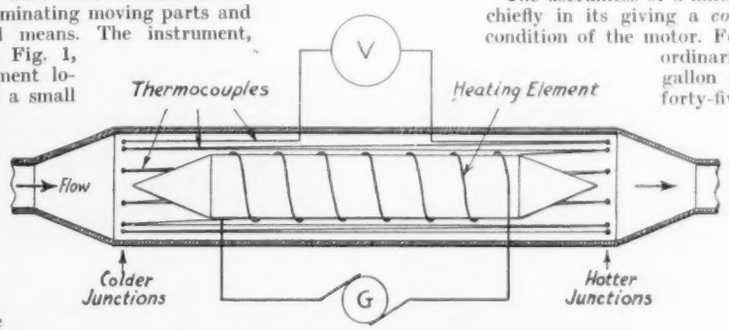


Fig. 1. Schematic diagram—actual construction differs.

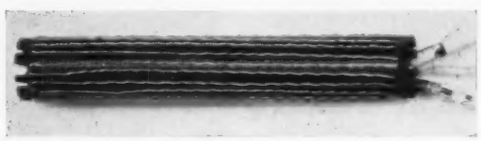
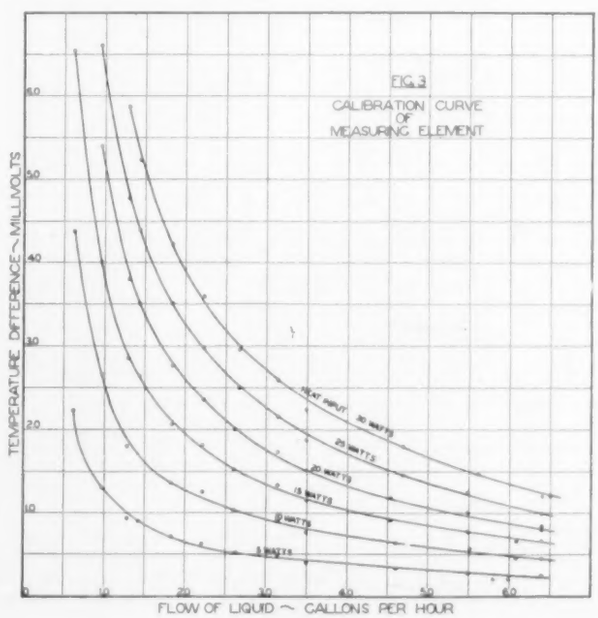


Fig. 2. Measuring element (two-thirds actual size).

The temperature rise, kept small (2 to 4°) to avoid vapor lock, is measured by a multi-couple thermoelectric element with its junctions placed alternately upstream and downstream from the heating coil. The millivoltmeter is graduated in miles per gallon. The differential couple measures only the rise in temperature of the fluid as it passes over the heating coil and, for practical purposes, the temperature of the fluid entering the element is immaterial. Other types of differential thermometers, such as the liquid-expansion or the vapor-pressure, can be used for this purpose.

An actual measuring element consisting of heating coil and ten-junction differential couple, removed from the conduit to show its construction, is shown in Fig. 2. The heating coil is contained inside the small fiber tube and the thermocouple wires are wound on the outside. The junctions are placed alternately on opposite ends of the tube and extend *into* the fluid stream which passes *through* the tube. This element is compact and shows a rapid response to changes in either fluid flow or heat input. In tests of this element, the millivoltmeter attained a steady value within a few seconds after a change in either of these variables.

A calibration plot of this particular element is shown in Fig. 3. The gallons per hour are plotted against the millivoltage generated by the ten-junction differential thermoelement. The plotted points were obtained by setting constant rates of flow and varying the watts input. Points of constant wattage were then joined to give curves which would correspond to constant speed in an actual installation. The alignment of experimental points shows the high degree of accuracy of the instrument.



The usefulness of a miles-per-gallon instrument lies chiefly in its giving a *continuous* indication of the condition of the motor. For example, if a car which ordinarily gives sixteen miles per gallon of gasoline at a speed of forty-five miles per hour falls off to fourteen at the same speed, the owner will know that the engine needs attention. The carbureter may need readjusting to compensate for changes in atmospheric conditions, or such parts as worn or sticking valves, fouled spark plugs, or worn pistons and rings may need repairing or replacing. These repairs or adjustments can also be made more quickly and correctly because the instrument will give a direct indication of their effect on the engine performance. Other uses for the instrument will no doubt occur to the reader. For example, bus and trucking companies would find it of value for indicating the most economical driving speed. Repair stations and manufacturers could use a portable form for testing purposes.

However, the use of the instrument is not limited to a miles-per-gallon indicator on an automobile. It has a general application as an efficiency indicator on any motor-driven equipment such as Diesel-electric plants, rail cars, or locomotives using liquid fuel. In short, it is a new instrument which will have numerous applications in all internal combustion engine-driven equipment.

This modification of the thermal type of fluid meter should find applications not only in connection with internal-combustion engines but wherever it is desired to measure the ratio between a fluid flow and a time-rate magnitude convertible into a proportional e.m.f. supply to the heater.—The Editor

*U. S. Patent No. 1,890,985.

Tests on Mercury Arc Rectifier Portable Substation Car

By E. A. TULUS*

PORTABLE substation cars—a significant new development in railroad engineering—contain equipment ordinarily housed in a small building. Some of this equipment—particularly mercury-arc rectifiers—must not be subjected to excessive shocks. But shocks are inevitable in normal running and coupling. The several companies responsible for this new development could not afford to guess the magnitude of the horizontal and vertical accelerations that may be imposed on sub-station apparatus by severe coupling operations or by bad track conditions. It was planned that the equipment would be moved from one place to another as a part of its normal operation, increasing the risk of disturbing the adjustment of some parts of the rectifier.

To measure these risks and to determine if special precautions would be necessary in the contemplated movements, numerous tests were conducted on the specially designed car to measure acceleration forces imposed on the equipment.

Fig. 1

Fig. 1 is an inside view of the cabin after the rectifier equipment has been installed inside of the car. This picture clearly demonstrates the importance of the knowledge of the forces imposed on the car when designing the equipment to stand actual service conditions. Fig. 2 shows a substation car with all the equipment installed on it.

Three sets of draft gears were used in the tests on the car. Each set consisted of a series of four elements in a steel case. These combinations of draft gear elements were made up of standard freight and passenger elements, stiff and flexible respectively, and used in the tests to determine the effect of such changes and select the best combination for the purpose. The load from each end of the draft gear was transmitted through to the opposite coupling, allowing the car to float on the gear. The final design as adopted after severe mechanical tests incorporated two flexible and two extra flexible spring draft gears connected mechanically in series so that there was four times the usual relative motion between the draft bar and the car frame for any given impact to the couplers. The arrangement of the drive gear has been developed by the Edgewater Steel Company, Oakmont, Pa. A continuous 4×4 in. steel draft bar through the car connected the couplers at opposite ends. In this way, external forces and shock involved in train movements were not transmitted to the car body or the equipment mounted thereon.

The apparatus used in this series of tests were:

(A) Portable substation car.
(B) Special test car.
(C) Flat car with farm lighting units for power supply.
(D) Steam engine and crew for movements.

The portable substation car, built by the American Car and Foundry Co., was weighed down with steel weights, equivalent in weight and distribution to the installed apparatus. The cable and wiring were attached to this car. Instruments—chiefly primary elements—were installed in the cab of the car.

The special test car was a railroad coach, which is adapted for this kind of testing. It was conveniently wired for connection at each end and contained a table on which the oscillograph was placed.

The power for these tests was supplied by two 2½ kw., 110-volt, direct current standard farm lighting units. To isolate any disturbances coming from these machines, they were mounted on a trailing flat car behind the test car.

The engine crew furnished five loaded coal cars for each test, into which the substation car was bumped. These coal cars had their air and hand brakes set to give greater resistance to the bumping shock. The cable reel was attached to the rear of the test car and unwound the cable when the sub-

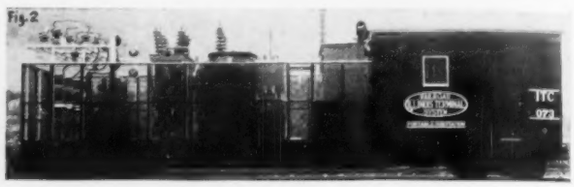
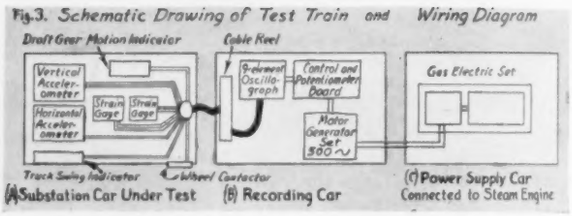


Fig. 2



station car was released for a bump. This protected the oscillograph and other apparatus from the actual bumping shock. Fig. 3 is a diagrammatic sketch of the test equipment with wiring of the measuring instruments.

DETAILS OF MEASURING INSTRUMENTS

Unique methods were employed in recording the physical movements and operating characteristics of the substation car during the bumping and running tests. A 9-element oscillograph was used, which recorded on 8 ft. film the graphical picture of the test. The following devices were connected electrically to give the desired data:

1. Timing device.
2. Wheel contactor.
3. Slide wire for draft bar motion.
4. Truck swing indicator.
5. Magnetic strain gauge to record draw bar stress.
6. Accelerometer.

1. *Timing device*—A tuning fork, Fig. 4, timed at 50 cycles per second, recorded on the film the short circuited periods of the coil which operated the tuning fork.

2. *The wheel contactor*, Fig. 5, was connected to a positive voltage source and grounded through the car. One of the four steel pegs on the periphery of a wheel on the substation car made connection every quarter revolution of the wheel. The oscillograph element was connected as a shunt for this contacting period.

3. *The slide wire* for measuring the draft gear motion consisted of two 4-ohm instrument resistances, Fig. 6, with sliding wire contactors. These resistances were rigidly mounted on the car body, end to end, and an arm extended up from the draft

*Industrial Motor Eng. Dept., Westinghouse Electric & Manufacturing Co.

Fig. 4. Tuning fork connections for timing.

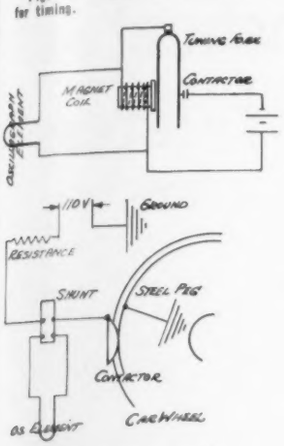


Fig. 5. Wheel contactor elements.

Fig. 6. Slide wire connections for indicating draft bar motions.

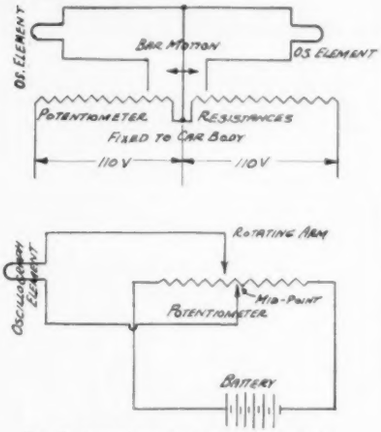


Fig. 7. Connections for truck swing indicator.

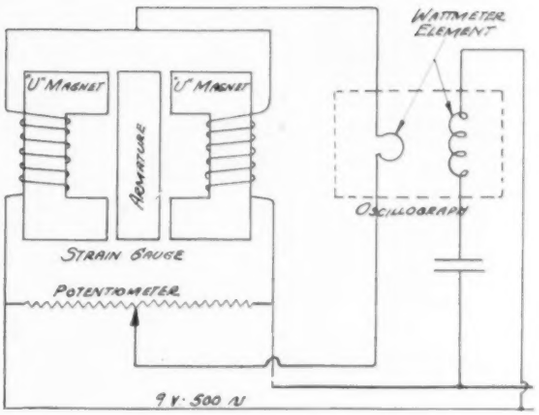


Fig. 8. Wiring diagram for strain gage.

bar to the resistance slider on each one. For motions in one direction, one resistance was affected, the other resistance remaining at the zero position. These resistances were each 12" long, the motions of 11" were recorded on the oscillograph film. Steel springs returned the sliders to the zero position as the draft gear returned to the mid position.

4. *The truck swing indicator,* Fig. 7, consisted of a rheostat having a revolving contactor which was connected to a large pulley. The indicator was rigidly connected to the car body, and a steel wire on the pulley was attached to the truck on the outside at the stuffing box. Thus, the rocking motion of the car while traveling at high speed or during a bump would be recorded as the trucks remain solid upon the tracks and the springs are between the axle bearings and the car body. For part of the tests, one of these truck swing indicators was mounted on each side of the car, and the oscillograph recorded the swinging motion of the car body.

5. The deflection and stress in the draw bar was measured with a *magnetic strain gage,* Fig. 8, consisting of two U-shaped non-permaneat magnets fastened to a base with machine screws, and with their open ends facing each other. Between the two magnets is placed an armature fastened to a slide, the slide in turn being fastened to the base by means of cross-head guides. The coils of the two magnets are connected in series and energized by 500-cycle current. After the gage was fastened to the draw bar, the armature was centered and the air gap adjusted to 0.008 in. on each side. The sensitivity of this type of gage depends upon the air gap between the armature and magnets—the smaller the gap the greater the sensitivity. The gap of 0.008 in. on a side gave 0.25 in. motion on the oscillograph film for 0.001 in. motion of the gage. The gage depends for its operation upon the change in reluctance of the two magnetic circuits as the armature is moved back and forth in the air gap. This change in reluctance gives a change in voltage across the coils of the magnets. The voltage across the one coil will increase, while the voltage across the other coil will decrease. It is this change in voltage across the coils that is measured and recorded by the oscillograph.

6. In order to measure the acceleration of the car, a *beam type accelerometer,* Fig. 9, was designed, similar in principle to the one of the Cambridge Instrument Co. The instrument consists essentially of two laminated springs with a mass suspended between these springs. Such an arrangement of the springs makes them very effective, thus reducing their length to a minimum. A magnetic gage was used for recording the oscillations through the oscillographic element.

The procedure of the test may be divided into two separate parts.

The first series of tests consisted in running the substation car into a stop with different values of the speed of "approach." Various railway men were consulted to learn their opinion as to maximum coupling speed and the value 6 miles per hour was chosen from this information as the worst possible case that may happen while the substation car was coupled to the other cars. Accordingly, the car under test was given different rates of speed from 2 to 8 miles per hour. A portion of a typical record taken during this first series of tests is shown in Fig. 10. The results of these "bumping tests" were plotted in curve form:

(1) Draft gear travel as a function of speed of approach.
(2) Horizontal acceleration of car body as a function of speed of approach.
(3) Vertical acceleration of car body as a function of speed of approach.
(4) Stress in drawbar as a function of speed of approach.

—each graph including the three curves of results obtained with the three sets of draft gear. Thus the "merits" of each of the three combinations of draft gear elements could be judged almost at a glance. An inspection of these four sets of three curves indicates without any doubt that one combination gives better performance and affords much better protection to the apparatus than do the other two.

A second series of tests was conducted to determine the performance of the car under running conditions. The car was run with different speeds ranging from 10 to 30 miles per hour. The plotted curves gave essentially similar results to the bumping tests.

These final tests settled definitely the choice of the draft gear to obtain the best protection for the rectifier equipment as well as for the structure of the car body itself. The values of accelerations in bump and running tests were found to be within limits safe for all equipment to be put on car for all speeds of coupling and running up to any expected in use.

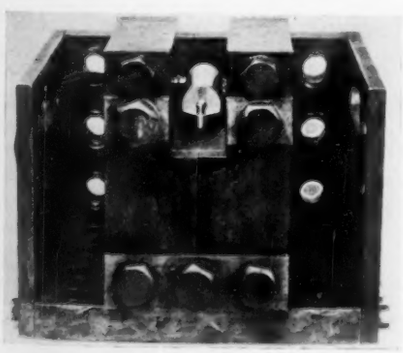


Fig. 9. Measuring element for car acceleration.

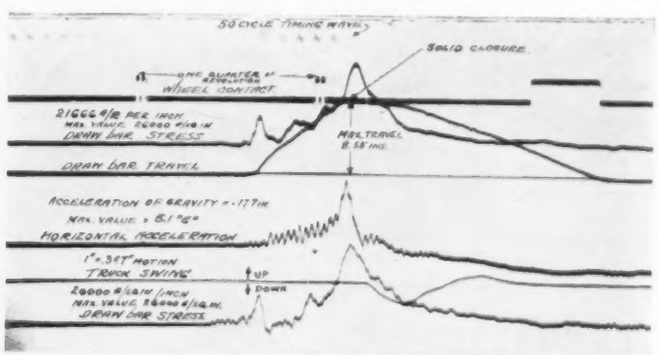


Fig. 10. Typical oscillogram of "bumping test" at speed of approach of 7 miles/hour.

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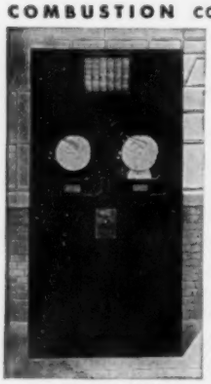

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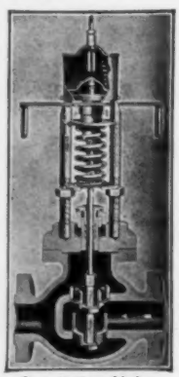

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Synchronism Indicators and Frequency Meters*

By PERRY A. BORDEN† and M. F. BEHAR**

1. Synchronism Indicators

In order to connect any synchronous generator or motor to another machine or system it is necessary that their terminal voltages agree not only in magnitude but in phase relation, *i.e.* in frequency, phase-rotation and phase-position. Phase rotation is usually made right once and for all when the machine is installed; but synchronism, *i.e.*, agreement of frequency and phase position, must be assured each time a machine is put on a line with other units. Many synchronous motors are arranged to start from rest as induction motors and pull themselves into synchronism without further attention on the part of the operator; and automatic synchronizing devices are available for some types of apparatus; but in general it is desirable to have some form of instrument or device for indicating (a) phase relationship between two a.-c. systems and also (b) which of the two is operating at the higher frequency. Synchronism indicators may be divided into two classes: (1) the lamp synchroscopes, which may or may not be true instruments; (2) the pointer type synchroscopes, all of them instruments, which of course require an electromechanical structure.

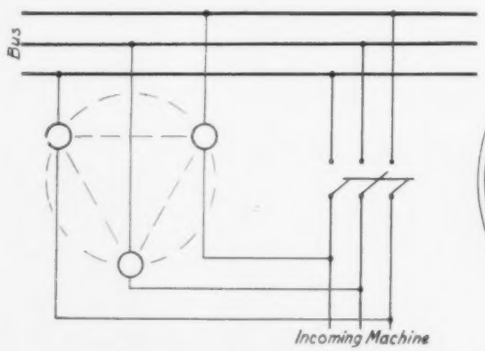


Fig. 36-1. Connections for 3-lamp synchronizing.

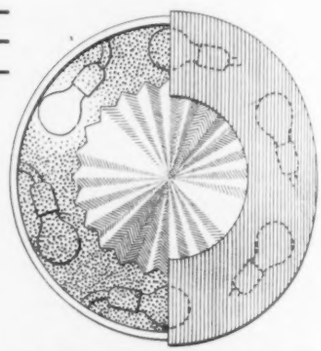


Fig. 36-2. Application of 3-lamp principle.

(a) Lamp-brightness Principle

Various schemes of operating with lamps, either with or without transformers, have been devised and their descriptions form a part of practically every textbook on elementary alternating current. These schemes need not be treated here, however, for with one exception they are of such low degree of precision as to be suited only to small units, and they are subject to the added handicap of furnishing no indication of relative speeds. The exception, particularly suited to three-phase systems, is based on a connection of three incandescent lamps between the two systems in the manner shown in Fig. 36-1. Note that one of the three lamps—the middle one—is connected between corresponding conductors of the two systems, while each of the other two is connected "across phases." With the two systems in synchronism, so that the switch can be thrown in without disturbance, the middle lamp will be dark, while the other two will burn with equal brilliancy. If the frequencies of the two systems differ slightly, the voltage applied to the terminals of one of these two will increase and that applied to the other will decrease. At the same time a voltage will make its appearance across the terminals of the middle lamp. If the three lamps are arranged on the corners of a triangle, as in the drawing, the illumination of the group will appear to rotate, one direction of rotation corresponding to the incoming machine being slow, and the other to it being fast, true synchronism being indicated by equal brilliancy in the "crossed"

*Eighth chapter (XXXVI) of Part Seven (Handbook of Industrial Electrical Measurements and Control) of Béhar's *Manual of Instrumentation*. See editorial announcement of this series on page A7 of November 1933 *Instruments*. A complete chapter of this new handbook will be published in each issue of *Instruments* throughout 1934 and 1935. Each chapter is subjected to a final revision, and then set in type, shortly before its appearance in this serial form, in order to assure that the subject matter is thoroughly up-to-date. This new book is not published serially in any other periodical. Entire contents copyright. To be issued in book form on or about Jan. 1, 1936.

†Member A.I.E.E. **Editor, *Instruments*

lamps—a condition which can be detected with considerable precision. This method requires no expensive apparatus and affords a highly satisfactory means of synchronizing when other instruments are not available. In making up such a system it is to be remembered that each lamp may be exposed to double the line voltage, so that if ordinary instrument transformers with 115-volt secondaries are employed, it will be necessary to use either 230-volt lamps, or else have two 115-volt lamps in series on each circuit.

(b) Lamp Synchroscope

This lamp method of synchronizing has been developed into a practical synchroscope by Siemens & Halske. Six lamps arranged in circle within a round case (see Fig. 36-2) are concealed by a cover having a large central opening exposing to view a dome-like surface (conical or hemispherical) projecting outwardly. This surface is fluted or "pleated" radially, and enameled white, so that when illuminated by the hidden lamps it shows sectors of light and shadow corresponding to which lamps are lit and which dark. These sectors appear in diametral pairs, opposite lamps being paired. As synchronism is approached, the effect is that of a diametral pair of dark sectors rotating. At exact synchronism these sectors become vertical and stationary while the illumination from the other four lamps is uniform.

(c) Neon Lamp Methods

Gaseous glow tubes, such as neon lamps, have found considerable application in the synchronizing of high-voltage systems. Connection is made without the use of instrument transformers, by employing capacitance coupling. This is frequently accomplished by tapping off a few sections of a high tension insulator and connecting directly to the lamps. The low power consumption of neon tubes makes it possible to do this without materially disturbing the distribution of potential along the insulator.

(d) Pointer Type Synchroscopes

The best known electromechanical synchronism indicators operate upon the Lincoln or the Weston principle. The Lincoln synchroscope embodies the same essential parts as the phase-angle indicator, preferably of the type having a complete 360-degree scale, the internal construction of the form manufactured by Westinghouse being originally practically identical with the power factor indicator shown in Fig. 35-5 of the preceding article on phase-angle measurements. The more recent (1933) construction is shown in Figs. 36-3 and -4, the closed network of windings which supplies the rotating field being replaced by a wound toroidal iron ring. This structure simplifies production and results also in an instrument with exceptionally low internal losses. Both windings are made of fine wire, the outer winding being connected to the bus through a reactance and a resistance (as in the power factor indicator) and the concentric inner coil to the terminals of the incoming machine, through a suitable series resistor. When the respective circuits are connected to two a.-c. systems the moving element will take up a position corresponding to their phase relation; and if the frequencies of the two are not identical the pointer will *rotate* continuously in a direction corresponding to whether the incoming machine is slow or fast as compared with the bus. The dial of such an instrument is shown in Fig. 36-4, and the markings thereon are self-explanatory.

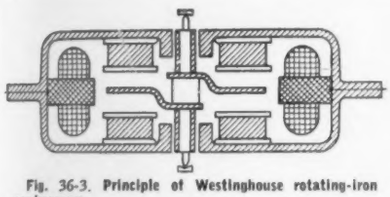


Fig. 36-3. Principle of Westinghouse rotating-iron synchroscope.

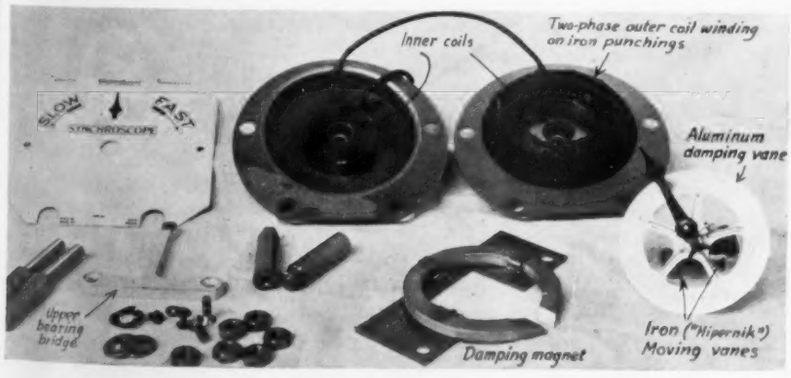
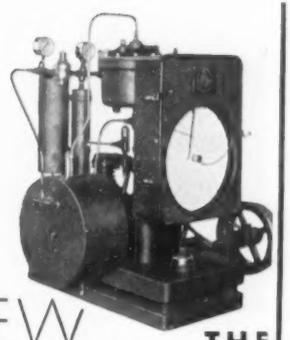


Fig. 36-4. Parts of the Westinghouse rotating-iron synchroscope.



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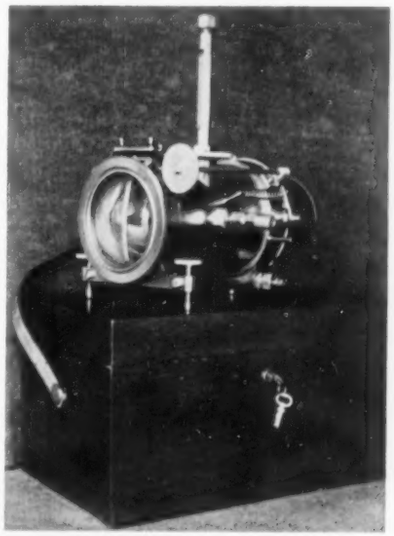

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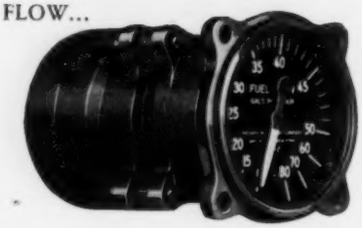

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The General Electric synchroscope (Fig. 36-5) operates on the same essential principle as the above but has a cylindrical armature with a crossed-coil winding connected to the bus through a phase-splitting circuit. Connections are made to the armature through slip-rings, so that it is free for complete rotation,

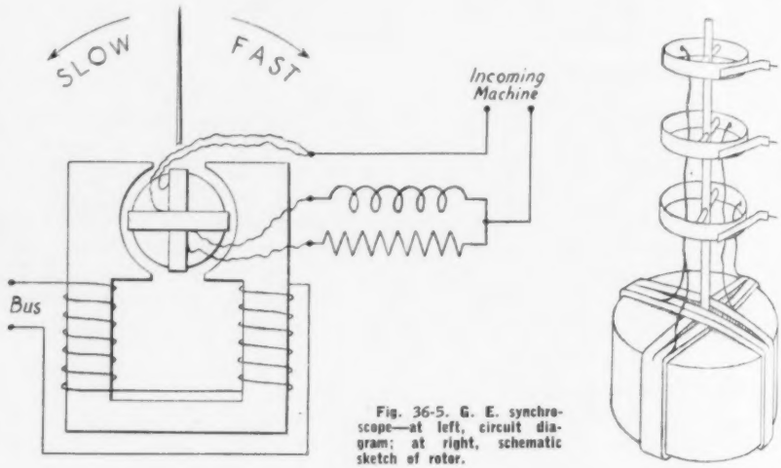

Fig. 36-5. G. E. synchroscope—at left, circuit diagram; at right, schematic sketch of rotor.

like the rotor of a motor. The field structure is excited by a winding connected to the incoming machine; and the performance of the instrument is substantially identical with that of the synchroscope described in the preceding paragraph.

In a more recent type of General Electric synchroscope, Fig. 36-6, the principle of operation consists of impressing the rotating fields from the running and incoming machines on a stator winding. An iron vane armature, free to rotate, then takes up a position dependent upon the resultant value of the two

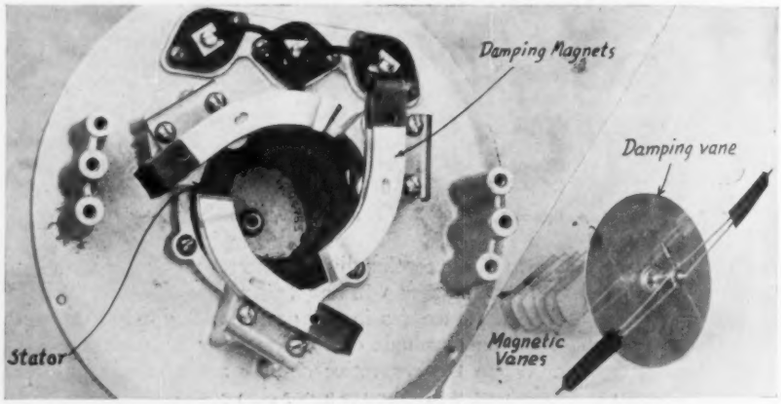

Fig. 36-6. G. E. rotating-field synchroscope, Type "AR-4," partly disassembled.

fields. Attached to the armature shaft is a double-ended pointer positioned to stand vertical when the two machines are in synchronism. A complete revolution of the armature indicates a gain or loss of two cycles in one machine relatively to the other.

The Weston synchroscope operates upon the electrodynamic principle, its structure being substantially that of a single-phase wattmeter having both its stationary and moving coils wound with fine wire. A diagram of this instrument is shown in Fig. 36-7. The stationary coil circuit is made slightly inductive and is connected to the bus. The moving coil is connected to the incoming machine through a capacitor, so that when the two voltages are in phase the currents in the respective windings will be in quadrature and the pointer will stand in its zero position, at mid-scale. As the voltage of the incoming machine lags or leads with respect to that of the bus, the pointer will *deflect* in a corresponding direction. If the machine is operating at a frequency different from that of the bus the pointer will *swing* from side to side; but a definite indication of whether the incoming machine is fast or slow is obtained by an ingenious combination of a synchronizing lamp with this measuring element: A

three-legged transformer has two primary windings excited from the bus and the incoming machine respectively; and a winding on the middle leg energizes a lamp directly behind the pointer, the connections being such that the lamp is lighted when the machines are approaching synchronism, is at maximum brilliancy when they are in phase, and is dark when they are in phase opposition. The pointer of the instrument is placed *behind* a translucent scale, on which its shadow is thrown when the lamp is lighted. Thus, as the pointer

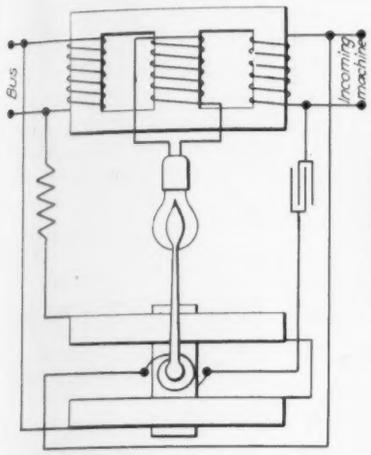

Fig. 36-7. Diagram of Weston synchroscope.

Fig. 36-8. Phantom view of Weston synchroscope.

swings back and forth, the shadow is seen sweeping across the scale as the machines pass through synchronism, but does not appear when they are in or near opposition. In this way there is produced the illusion of continuous rotation in a direction corresponding to whether the incoming machine is fast or slow, and the visual indications are like those of a rotary synchroscope. Fig. 36-8 is a phantom view of this instrument (in the round case: it is now being made up largely in the new square case).

2. Frequency Measurement—General Notes

With the advent of interconnected power systems, and the almost universal use of controlled frequency for time-keeping and timing purposes, the problem of frequency measurement in alternating systems has taken on quite a different aspect from the day when isolated plants were the rule and the total number of alternations per day a matter of little or no consequence. At the same time, since the frequency must of course be the same at all points of a system, the total number of frequency-measuring instruments required in proportion to the amount of power generated has tended to become less. The present-day requirement for a frequency meter* is usually for an instrument having a long scale for a short range of frequencies, hence capable of a high degree of precision. As pointed out in the Preface, the scope of this book is industrial, so that high-frequency (radio, audio, etc.) measurements will not be treated.

Since practically all alternating current at commercial frequencies is derived from dynamo-electric machinery, a determination of the *speed* at which the generating apparatus operates will provide a basis of frequency measurement, so that a purely mechanical type of speed indicator or tachometer associated with the generator either by mechanical connection or through the medium of a synchronous motor may be calibrated in terms of the frequency F by applying to the speed $\mathcal{N}$ expressed as revolutions per minute the formula $F = \mathcal{N}P/120$ where P denotes the number of poles on the field structure. As this Part of the Manual deals with essentially *electrical* measuring instruments, however, mechanical speed indicators and recorders which may be used for frequency measurement will not be treated here; and for detailed descriptions and discussions of such instruments the reader is referred to Part Five, especially Sections 10 and 20 of Chapter XXI.

Instruments which determine the frequency of an alternating current source without mechanical connection to rotating machinery may be classified as (1) Electromechanical, and (2) Electrical.

*"Indicator" would be better, in view of the trend toward using "meter" (as a separate word, not a suffix) to denote a quantity-measuring device, i.e., an integrator. The authors heartily support this trend but conform to the A.I.E.E. standard which has not yet been amended with regard to frequency measuring instruments.

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MANUFACTURERS' NEW LITERATURE

In this department we each month list the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

B257 **Portable Electrical Instruments.** Price sheet 7 for catalog 123 covers a new line of portable measuring instruments known as Types NPD and NPA for d.c. and a.c. respectively. Roller-Smith Co., 233 Broadway, N. Y. City.

B258 **Laminated Bakelite.** The Synthane Corporation of Oaks, Pa., announces an interesting new LAMINATED BAKELITE SAMPLE BOOK. The book is a handy pocket size and is profusely illustrated. A distinctive feature is the presentation of actual samples of the material. Samples of Synthane have been slipped into paper envelopes on the right hand pages from which they can be easily removed for inspection. On the opposite, left hand pages, the properties, characteristics, colors, sizes, grades and thicknesses are condensed to short paragraphs that can be read in a few moments. Standards of quality and test values are in the back.

B259 **Directional Overcurrent Relays.** Types CR and CRA Directional Overcurrent Relays is the subject of a new 12-page illustrated publication recently issued by the Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa. Intended primarily to sectionalize transmission lines, these relays may also be used for the protection of generators subject to feed-back from other sources. The leaflet contains the most complete information on the subject ever published including a discussion of applications, distinctive features, construc-

3. Electromechanical Frequency Meters

The best-known of the electromechanical class of frequency instrument is the Frahm vibrating-reed type. The measuring element, Fig. 36-9, consists of a row *R* of thin spring steel reeds of gradually varying lengths, each about ⅛ inch wide, rigidly fastened at one end to a bar or "bridge" *B*, their outer ends free to oscillate, with tips bent at right angles and enameled white for visibility. Vibration is produced inside the instrument by electromagnet *M* actuating armature *A* mounted on the bridge-piece to which the calibrated reeds are attached. The magnet, connected to the circuit through series resistor *G*, imparts to the comb one impulse for each cycle, if the core of the electromagnet be biased by a permanent magnet, or two impulses if unbiased. That reed whose natural period most nearly approaches that of the armature will respond most vigorously, thus providing a visual indication of the frequency. This instrument is available in a number of forms and ranges but not as a recorder. By means of a magnetic biasing device it is possible in some models

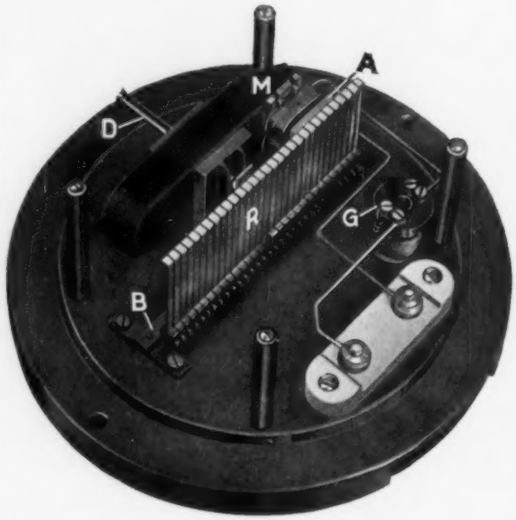

Fig. 36-9. Interior view of vibrating-reed frequency meter (Biddle).

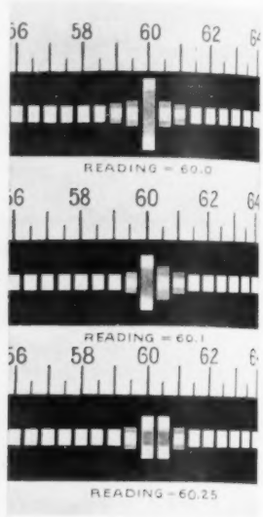

Fig. 36-9A.

to double the range of the instrument. In general, one reed is provided for every quarter-cycle in ranges below 30 cycles, for every half-cycle between 30 and 60 and for every whole cycle when the mid-point (normal frequency) is more than 60. The upper limits are 180 for switchboard frequency meters and 200 for portable models.

While it might at first appear that this type indicates only certain fixed frequencies, the following statement by the makers makes it plain that a reasonable degree of interpolation is easy (except, of course, when the frequency varies too fast for the observer):

"The vibration of each reed begins at about 2% below the exact value to which the reed is tuned, reaches its maximum at the exact value, and extends to about 2% above that value. Therefore more than one reed usually is in motion, and from the respective lengths of the bands seen in the scale opening the exact value of the frequency may be estimated down to one-fourth of the interval between successive reeds. Reference to the three different scale images in Fig. 36-9A will make this feature clear. On the upper scale the reading is evidently 60. On the lower scale, the reeds indicating 60 and 60.5 are vibrating equally, so that the reading is *half way* between these two values—that is, 60.25. On the middle scale, it will be seen that the reed indicating 60 is vibrating more than any other, so that the reading is therefore nearer to 60 than to any other scale division. Furthermore, the reed indicating 60.5 is in next greatest vibration, so that the reading is again between 60 and 60.5. However, the reed indicating 60 is vibrating with an amplitude about three times that of the reed indicating 60.5, so the reading is *one-quarter way* from 60 toward 60.5 instead of one-half way. That is, the reading is 60.1, or approximately 60.1."

These instruments are not affected by ordinary wave-form distortions. Their reeds are of material having a negligible temperature error. The accuracy of each individual instrument depends on the tuning of every reed in its comb, so that any statement giving the definite limit of error of this type would be rash. Since, however, severe service makes an individual reed lose its calibration, an instrument in service is likely to lose its accuracy first in the scale region most used. Adjustment then consists in tuning—like a piano.

4. Electrical Frequency Meters

An electrical frequency-measuring instrument may employ such mechanical devices as a vane, a shaped disk, a recording mechanism (if it be a graphic), or even a thermostat-controlled crystal (if it be a laboratory precision model); but it is essentially a frequency-sensitive electrical apparatus or a frequency-sensitive electrical network.

(a) Ratio-type Instruments

The majority of purely electrical frequency meters operate on some adaptation of the principle of balance between circuits having different time constants, and therefore carrying currents whose values will vary with changing frequency, the moving element being subject to no mechanical control force. In the simplest form the moving windings of a crossed-coil instrument similar to the power factor indicator (Fig. 35-2) are energized through an inductance and a resistance respectively, and the stationary coil is connected to carry the resultant of the two currents, as shown in Fig. 36-10. Special compensations are generally provided to counteract the effects of wave form and voltage variation. Two frequency meters of the opposition or ratio class, which differ from the conventional crossed-coil form in having iron in their magnetic circuits, are the Westinghouse induction type and the Bristol balance type.

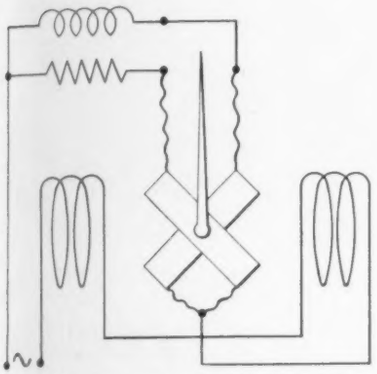

Fig. 36-10. Diagram of crossed-coil frequency meter.

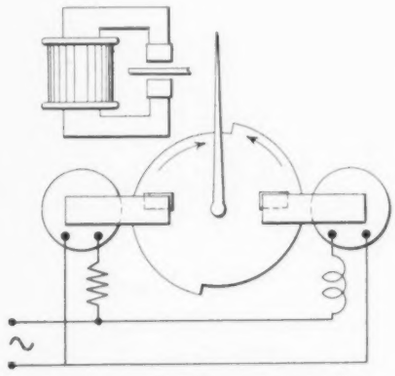

Fig. 36-11. Westinghouse induction frequency meter.

In the Westinghouse induction-type instrument (Fig. 36-11) two alternating-current electromagnets with shading rings act upon opposite sides of a disk, rotating it to a position where the opposing torques balance each other. One magnet coil is connected to the line through a resistance and the other through an inductance. As the relative distribution of currents in the magnet windings depends upon the frequency of the voltage the position of the disk and attached pointer provides an indication of the frequency of the system.

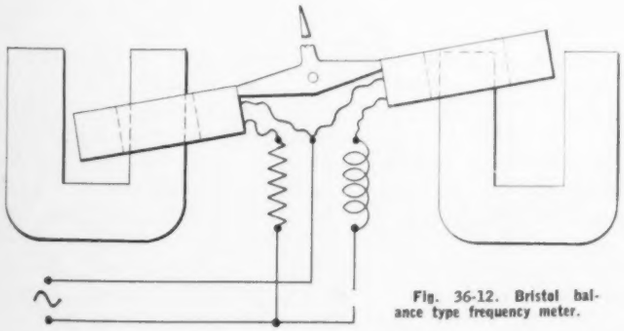

Fig. 36-12. Bristol balance type frequency meter.

In the Bristol balance-type frequency meter (Fig. 36-12) two short solenoids are balanced on a beam, and each fits loosely over an open iron core. Owing to magnetic leakage the inductance of each coil increases the more completely it encircles the core, thus tending to reduce the flow of current. One coil is energized through a resistance and the other through an inductance. Because of the differing time-constants of the circuits the currents in the two coils vary differently with frequency changes, so that the position of balance becomes representative of the frequency of the system.

tion and operation. Also, wiring diagrams, time curves and prices are included.

B260 **Supervisory Control.** A new publication, entitled Polaricode, Jr., has recently been published by the Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa. The publication describes the application, distinctive features and operation of this low cost simplified supervisory control system. Especially applicable for small stations which do not justify the expense of higher cost systems, it is available in one size only and is limited to and equipped for a total of five selective, complete operations. It is ideal for the control of small hydro plants out on the creeks, oil line pumping stations, electric railway and mining substations and municipal water pumping stations.

B261 **Be Our Guest.** This is the title of a little leaflet issued by Hygrade Sylvania Corp., Emporium, Pa., inviting everyone to plan their summer travel to include a visit to their three plants at Emporium, Salem, Mass., and Clifton, N. J.

B262 **Rheostats & Resistors.** Catalog No. 10, eight pages of helpful information concerning the use of these items in radio and electrical work. It lists many new types of resistors, power rheostats, and replacement units. Ohmite Manufacturing Co., 636 N. Albany Ave., Chicago, Ill.

B263 **Electronic Contactor Timers for Spot Welding.** For applications where the extreme accuracy of Ignitron timing is not essential, the electronic contactor timers for spot welding described in a 2-page leaflet issued by the Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa., have wide application where a low maintenance timing device is desired. This illustrated leaflet describes the application, distinctive features, operation and construction of the electronic contactor timers.

B264 **Spring Testing Machine.** Leaflet gives details and specifications of a pendulum indicating spring testing machine. Coats Machine Tool Co., Inc., 110 West 40th St., New York City.

B265 **Adjustable Flow Control.** Leaflet No. 205 illustrates and describes the new adjustable Flo-trol valve. Carrick Engineering Co., Michigan City, Ind.

B266 **Air Conditioning.** New catalogue "Lewis Air Conditioning" illustrates the 1934-35 line of air conditioning equipment. Lewis Air Conditions, Inc., 829 Second Ave., South, Minneapolis, Minn.

B267 **Photo-Relay.** A new publication describing the Westinghouse Type LE Photo-Relay has recently been published. It describes the application, construction, operation, specifications, advantages, and list prices of these relays. These relays are applicable to all types of industrial control, light control, grading, counting, etc. The relay is available for either a.-c. or d.-c. circuits. Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

B268 **Temperature Control.** Barber-Colman Co., Rockford, Ill., have issued a number of data sheets on their equipment: T-10 Thermostats; H-10 Hygrostat; V-10, V-20, V-40, V-50, V-80, V-90, V-100 and V-110 Motor-Operated Valves; V-120 Solenoid Valves. Three separate bulletins cover the following subjects: Automatic Electric Controls for Central Station Steam, Single-Point Control for Forced Warm Air Duct Systems, and Compensated Control for Zone Temperature Maintenance.

B269 **Spectrographs and Spectrometers.** This 32-page booklet of the Bausch & Lomb Optical Co., Rochester, N. Y., presents the B & L line of spectroscopes, spectrometers and smaller spectrographs for the visual range.

B270 **Radio Tube Manual.** The Technical Manual of Sylvania Radio Tubes is a 100-page booklet and gives information on tube characteristics. Price 10c. Compiled and published by Hygrade Sylvania Corp., Emporium, Pa.

B271 **General Radio Experimenter.** The June issue of this publication contains the following articles: New Developments in Electron Oscillography, New Acoustic Response Recorder. General Radio Company, 30 State St., Cambridge A, Mass.

B272 **Temperature & Pressure Controller.** Four-page bulletin describes an inexpensive, dependable, accurate, positive controller for temperature and pressure. Foxboro Company, Foxboro, Mass.

B273 **Finger Print Magnifier.** Leaflet discusses finger print identification using this magnifier. Prices given. Bausch & Lomb Optical Company, Rochester, N. Y.

B274 **Taylor Rochester.** The Spring-Summer 1934 issue of this publication contains the following: Early weather notes, Rain-Wash, Billionaire Pirate of Modernity, The Wonderful Halo Family, President's Committee Recommends Improvements in Weather Forecasting, The Eye of the Storm, Safety Device Where School Children "Wade the Clouds." Taylor Instrument Companies, Rochester, N. Y.

B275 **Research Microscopes.** One of a series of catalogues issued by the Bausch & Lomb Optical Company, Rochester, N. Y. This catalogue covers the line of research microscopes and accessories. 24 pages.

B276 **Reduced Voltage Starters.** Bulletin GEA-1979 is entitled G-E Reduced-Voltage Starters, Auto-Transformer Type for Squirrel-Cage Induction Motors. 12 pages. General Electric Company, Schenectady, N. Y.

B277 **Automatic Furnace Pressure Control.** Bulletin 842 describes the L & N automatic furnace pressure control for metallurgical and other industrial furnaces. Leeds & Northrup Company, 4901 Stenton Ave., Philadelphia, Pa.

B278 **Recording Thermometers.** Four-page bulletin on a new recording thermometer. Bulletin 3076-C. Mason-Neilan Regulator Co., 1190 Adams Street, Boston, Mass.

B279 **Farnfron Relay.** Four-page leaflet (Bulletin 20) illustrates this electronic relay. Lumenite Electric Co., Old Colony Bldg., Chicago, Ill.

B280 **Electrical Measuring Instruments.** Catalog No. 34 is a complete catalogue of the various instruments manufactured by the Sensitive Research Instrument Corp., 4545 Bronx Boulevard, New York, N. Y.

B281 **Rate of Heating Control.** Leaflet lists advantages of regulating rate of heating in electric furnaces. Lindberg Steel Treating Co., Chicago, Ill.

B282 **Photomierographic Equipment and Accessories.** 24-page bulletin illustrating the B & L line of instruments. Prices are included. Bausch & Lomb Optical Company, Rochester, N. Y.

B283 **Micro-Projector.** Four-page bulletin describes this instrument and gives prices. Bausch & Lomb Optical Co., Rochester, N. Y.

B284 **Microtomes.** Before looking over this 28 page bulletin we did not know that there were so many different microtomes. Bausch & Lomb Optical Co., Rochester, N. Y.

B285 **Seamless Metal Hose.** Bulletin 344 contains valuable technical information which will be of considerable interest to anybody who is charged with the responsibility of selecting flexible metallic hose. Seamlex Corp., 5-19 48th Ave., Long Island City, N. Y.

B286 **Galvanometers.** Bulletin 320 describes and illustrates a complete line of galvanometers and reading devices. Rubicon Co., 29 North 6th St., Philadelphia, Pa.

B287 **Surface Pyrometers.** Bulletin 1727 illustrates pyrometer models for roll surface temperature measurement, rubber, wax and non-metallic materials, molten metal and bakelite molding dies. Illinois Testing Laboratories, Inc., 141 W. Austin Ave., Chicago, Ill.

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(b) Electrically Resonant Frequency Meters

Modern demands for high sensitivity in frequency determination have been met by combining the opposition or ratio class of movement with an electrically resonant circuit. The constants of the electrical circuits are so proportioned that resonance occurs at or near the mean frequency of the system upon which the instrument is to be used; and thus the sensitivity through a limited range is greatly increased.

A diagram of a recent General Electric instrument embodying some interesting features is shown in Fig. 36-13, and a section of its interior in Fig. 36-14. The two field windings F_1 and F_2 are of opposite polarity. The single moving coil A carries the sum of the currents in these coils. Thus, for any position of coil A, the torque or turning tendency will be proportional to the product of the sum and the difference of the currents in the two field coils. The introduction of the difference of the two currents in the torque equation is responsible for an exceptionally high sensitivity, because the difference of two magnitudes which are almost equal varies rapidly with relatively small changes in these currents themselves. Control torque is derived from a magnetic vane V attached to the moving element and tending to maintain coil A with its axis perpendicular to that of the field coils. The inductances and capacitances are so proportioned that one of the field coil circuits resonates at a frequency several cycles above the mid-point of the range and the other a similar extent below. With this arrangement the change of current in either of the circuits is much greater than the change of frequency, so that the combination of the resonant circuits with the movement described produces a frequency-measuring unit whose accuracy may be said to be limited only by the constancy of the capacitors and inductances available.*

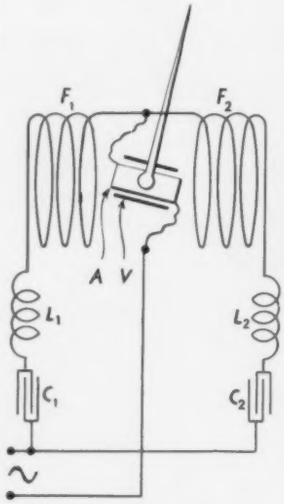


Fig. 36-13. Diagram.

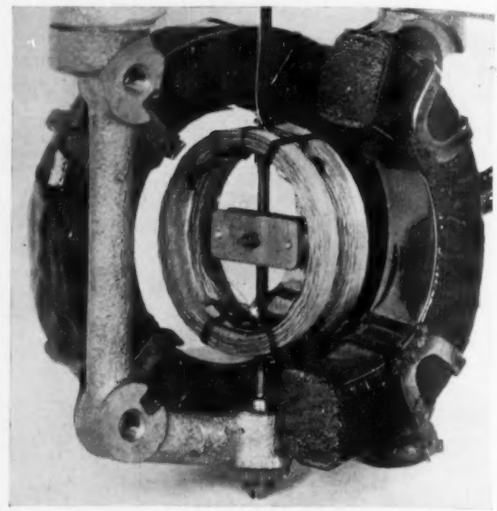


Fig. 36-14. Measuring element with one coil cut away. General Electric resonant circuit frequency meter.

In the Weston frequency meter (Fig. 36-15) there are two fixed coils fitted together at right angles. The principal part of the moving element is an iron vane subjected to the resultant field of the two coils. Since there are no control springs, not even flexible conducting filaments, the vane is perfectly free to rotate within its range. In series with one coil is a reactor X_1 and with the other a resistor R_1. In parallel with the first coil and its reactor is a resistor R_2, and in parallel with the second coil and its resistor is a reactor X_2, the whole combination being connected in series with reactor X whose purpose it is to damp out harmonics in the line voltage. The system thus forms a bridge circuit, and is adjusted to balance at the normal frequency. A change in frequency will unbalance the currents in the two coils, with a corresponding shift in the space position of the resultant field; and, as the vane tends to maintain alignment with the field, the pointer will have a definite position for each value of frequency within the range of the instrument.

In the Westinghouse resonant-circuit instrument (Fig. 36-16) a single resonant circuit of the parallel type is used, which results in an exceptionally low volt-ampere burden. Mechanically the instrument is similar to the ratio-type frequency meters. The current in an inductive circuit passes through the fixed coil and one moving coil of the element. The voltage across a portion of

*See B. W. St. Clair's article in *Instruments*, Vol. 2, Nov. 1929, pages 371-377.

this circuit is applied to a capacitor, and the resultant of the former current and the capacitor current passes through the other moving coil. The currents in the two moving coils are thus virtually 90 degrees out of phase with each

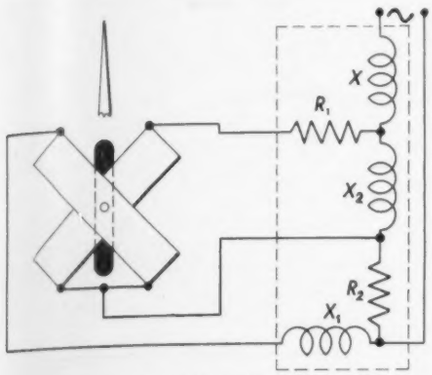


Fig. 36-15. Weston.

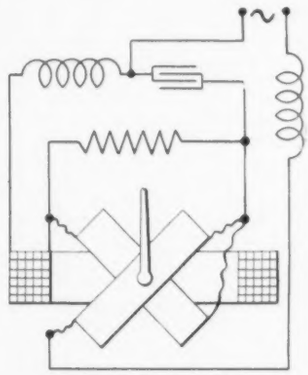


Fig. 36-16. Westinghouse.

Diagrams of resonant circuit frequency meters.

other, and their relative magnitudes vary with the frequency of the applied voltage. The moving element tends to take a position in which the resultant axis of its field coincides with that of the stationary coil, so that the position of the moving element depends upon the frequency of the system.**

(c) Other Instruments

The principle of the synchronous-motor-driven tachometer, and that of the self-balancing frequency bridge, are utilized in graphic frequency meters. These instruments are of the relay type, and will be discussed in a subsequent article on Recording Electrical Instruments.

**See Paul MacGahan's article in *Instruments*, Vol. 3, March 1930, pages 197-199.

INSTRUMENTS BOOK SHELF

Thermostats and Temperature Regulating Instruments. By Roosevelt Griffiths. J. B. Lippincott Company, Philadelphia, 1934. Cloth, 6 x 9 inches, 157 pages. Price $5.00.

The author aimed "to give a brief sketch of numerous types of thermostats" . . . "which will prove of service to the investigator who has need for automatic control of temperature." The result is in the main an assemblage of unedited notes briefly describing some of the finest types of temperature controllers and occasionally expanding with the details of inferior or impractical makeshifts.

The book cannot be recommended to the novice because of its numerous errors and lack of perspective, nor to the experienced because it is too sketchy to offer at the quoted price. No attempt was made to digest the information and misinformation obtained from makers of industrial instruments, or to compare the capabilities of various types of thermostats. The author is familiar with some of the laboratory types of thermostats and gives a number of references about them but has had to rely on catalogs and advertising statements about industrial types. Some of this advertising is almost as misleading as that of vacation resorts. The kind of error which the reviewer finds particularly annoying is typified by "When the capsule expands sufficiently, the valve stem is raised . . ." which should read: "As the capsule expands, it raises the valve stem." The author repeatedly uses "when" in place of "as" or "while"—an error which is quite significant in comparing various kinds of mechanisms.

It is surprising, to say the least, that the author, a lecturer in a university, should let a publisher have his manuscript in such an unfinished form, showing respect neither for his subject, nor for the English language nor finally for the reader. The reviewer does not mean to imply, however, that mere editing would make the book valuable. —C. O. Fairchild (2.06)-B-

Theoretical Physics. Vol. II. Electromagnetism and Optics: Maxwell—Lorentz. By W. Wilson. Methuen & Co., Ltd., London; E. P. Dutton & Co., New York; 1933. Cloth 5¾x9 inches. 315+xii pages. Price $5.75.

This book is one of a few, written in the last three years, that mark the transition from the classical to the modern form of texts on electricity and light. Unlike one or two others, though, it does not dismiss x, y, z, t and $\sqrt{-1}$ in the first chapter and proceed to build with meta-mathematical tools an infinite number of extra-scientific subethers where everything is possible except a Creator. Unlike some others it does not compromise with its aim by stooping to the mental level of students who are utterly lost without the trite and false mechanical analogs. Nor is it a college text with the traditional examples and problems. As the title promises, it is purely a treatment of theoretical—not experimental—electromagnetism and optics, featuring electromagnetic mass and momentum (whence the sub-title "Maxwell—Lorentz") as an introduction to relativity, but Professor Wilson never hesitates to refer to verifiable experimental foundations and includes a profusion of apt illustrations—both graphic and verbal. Thus, he opens Chapter I (Electrostatics) with a section on familiar electrification phenomena that a schoolboy could understand, and he closes Chapter XV (General Questions Concerning the Propagation of Light) with a summary of Michelson's experiment. This last chapter is a delectable gem that makes the reader hope that the publishers will soon bring out Vol. III where Wilson will take up relativity and quantum dynamics.

In between come rigorous treatments of magnetostatics, electrodynamics, alternating currents, Maxwell's theory, electron theory, dispersion, scattering of radiation—in all some 150 or 200 topics which all differ from one another while all of them pertain to electricity and light. The author's chief consideration in selecting the subject-matter was its importance with regard to "presenting physical theory as a coherent logical unity" (preface) and he modestly adds "I make no claim that my choice of the material is the best that might have been made."

Be that as it may, his arrangement of the subject-matter is masterly, and his treatment displays an artistry comparable in its way to the Ninth Symphony or to Sordello—which particular examples suggest themselves to me because Professor Wilson composed this volume for an audience even more select than Beethoven's or Browning's. Before the First World War one of my intimate friends was the concertmaster of a great symphony orchestra, and all these troubled years have not made me forget his hobby of savoring symphonies from their printed scores—which pleasure he could give himself even in a crowded subway car! I have always regretted my hopeless inability to combine such sight-reading ability with so keen an intuitive understanding of harmony and counterpoint; and now I find myself suffering from another inferiority complex as I realize that the mathematical equipment of the average engineering graduate does not fit one to savor "at sight" all the beauties of *both* kinds of post-Einstein presentations of "physical theory as a coherent logical unity." One is the new genre of rather florid belles lettres reaching its full flower in Chapters IV, VIII, XIV and XV of Eddington's "The Nature of the Physical World," which may be enjoyed *passively*. The other, exemplified by Wilson's book, is the chaste, unadorned mathematical essay which means nothing to the profane but yields to the initiate a reward the richness of which is proportional to the degree of his initiation raised to the power of his application.

Which is to say that the "average engineer" who has taken differential and integral calculus will get a good deal of effortless enjoyment out of this book; and moreover he will want to acquire at least a smattering of tensor analysis, non-Euclidian geometrics and modern wave theory in order to make a few altitude flights, on the wings of Wilson's work, to those lofty regions where he may catch thrilling glimpses of what Whitehead père visioned when he declared that "every branch of physics gives rise to an application of mathematics. A prophecy may be hazarded that in the future these applications will unify themselves into a mathematical theory of a hypothetical substructure of the universe, uniform under all the diverse phenomena."

M. F. Béhar (4, 5, 7)-B-

Elements of Geophysical Prospecting. By C. A. Heiland. Colorado School of Mines, Golden, Colo., 1933. Paper, 6x9 inches, 52 pages.

Primarily, this little book is a description of the Colorado School of Mine's geophysical prospecting exhibit at A Century of Progress, Chicago. Actually it is an interpretation of this noteworthy exhibit; which is to say that it is an outline of the fundamental principles of geophysics. "It has been written not only for the benefit of those who have seen the exhibit and wish to add to their knowledge gained by witnessing it by studying an elementary summary of the field, but also for those who have not had an opportunity to visit it." Numerous full-page and half-page illustrations show the charts and the "still" exhibits, and convey some idea of the animated exhibits, these latter being credited largely to Charles H. Hull, Instrument Maker of the Colorado School of Mines, while the real geophysical instruments on view are loaned by the American Askania Corp. and by Geophysical Service, Inc. Prof. Heiland's text, while sufficiently elementary to appeal to the non-technical man, covers all known methods, gives the highlights of geology, presents important statistics and ends with an extremely useful one-page detailed tabulation of the characteristics of the four principal geophysical methods—the "electrical method" for example being split up into five distinct methods. —M. F. Béhar (10)-B-

NEW INSTRUMENTS

Write Information Section, Instruments Publishing Company, for additional information.

Ultraviolet Intensity Instrumentation

Hanovia Chemical & Mfg. Co.

INDICATING, recording and full-automatic control devices for ultraviolet radiations are announced, completing the instrumentation of U.V. intensity. The *Indicator*, Fig. 1 (mfd. by Weston to Hanovia design), consists of a Photronic self-generating cell "target" with suitable filter excluding visible light, connected to a triple-range microammeter. Conversion factor tables enable observer to obtain results in microwatts /cm.²/sec. of activating ultraviolet energy for various sources. No external electric energy is required by the outfit which is self-contained in quartered oak box 8½"x4¼"x8¾" and weighs 7½ lbs. Each instrument is calibrated against standards checked by the National Bureau of Standards. The *Recorder*, Fig. 2, consists of a generally similar Photronic receiving element connected to a 30-day strip-chart (Engelhard Type S) recording milliammeter in a moisture-, dust- and fume-proof case 18"x14"x10½". The *Automatic Controller*, Fig. 3, especially designed for such processes as the vitamin D activation of milk, has for its specific function the regulation of wattage input to the quartz mercury arc lamps (or other sources) employed in such processes. In Fig. 3, an indicating microammeter is shown commanding the operation of a voltage control motor, but a system of relays or Thyratron tubes may be used instead. This control system maintains the predetermined ultraviolet intensity by compensating both for lamp deterioration and for line voltage fluctuations. The Photronic cell and its filter normally show no "fatigue" but of course require cleaning to prevent apparent lowering of sensitivity. These receiving elements (for the measuring or controlling instruments) should not be subjected, however, to temperatures $> 160°F.$, responding a sthey do not only to wave-length between 2500 and 4000 A.u. but also to the near infrared and being subject to heat deterioration. No corrections are required for the temperatures at which these receivers are normally used; a table is furnished giving the (slight) percentages to be added to readings at low temperatures of cell.

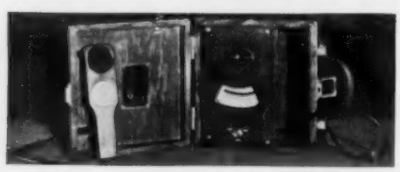


Fig. 1

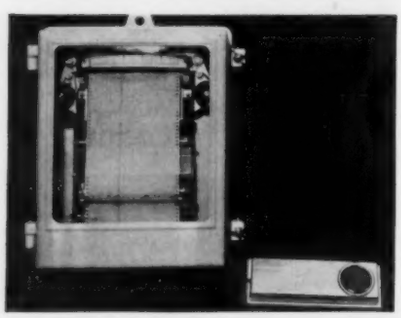


Fig. 2

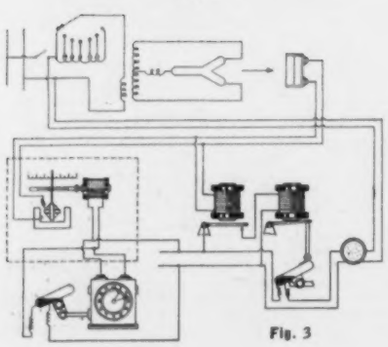
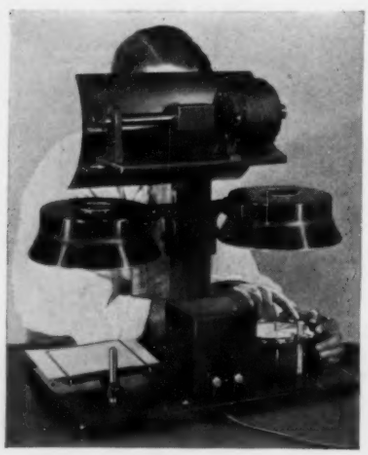


Fig. 3

New Type Color Analyzer

Bausch & Lomb Optical Co.

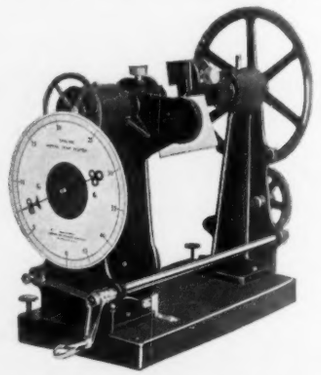
MEASURING color in terms of its psychological attributes of (1) hue, (2) saturation and (3) brilliance, and therefore providing a true "analysis," the new H-S-B Color Analyzer differs from the spectrophotometer which measures separate colors according to radiant energy, in that it uses the Munsell color disks and provides a method of integrating colors by a numerical system from which a desired formula may be obtained. The system has been so designed optically that actual rotation of the disks is avoided. In left-hand light path is placed a prism, the rotation of which causes a circle to be scanned upon the disk surfaces. The prism is mounted in the hollow shaft of a specially designed shaded-pole motor, mounted directly in the optical path so that the light beam passes along its axis of rotation. (Photograph is back view showing illumination units, special motor and prism box—eyepiece is in front center near prism.) Elimination of belts, gears and pulleys renders instrument quiet in operation. Speed is sufficient to eliminate flicker due to brilliance and color. With new system of scanning the stationary disks, complete adjustments are made rapidly, since one simply views the photometric field and alters the sector of the stationary disks until a satisfactory match is secured. In the optical system on the sample side there is a negative lens mounted in a slide so that it may be introduced into the light path at will. The purpose of this lens is to provide a larger field of view where a sample is of uneven color. With the negative lens out of the system, the specimen field covered is approx. 1"; with lens in, field is approx. 3". Daylight filter in eyepiece serves to set up conditions which closely approximate north skylight. Paper, paint, powders, coarse and fine ground materials, liquids, creams and emulsions, fibers, woven materials, etc., are conveniently analyzed. Even such materials as hay, cotton, coffee, and grains have been analyzed at the Department of Agriculture.



Initial Tear Paper Tester

Thwing Instrument Co.

FOR certain services, the value of paper depends on its resistance to the *beginning* of a tear. The Thwing Initial Tear Tester measures this initial force. It is especially suitable for determining the strength of materials used in the manufacture of shipping containers such as open built-up fibre board boxes that are likely to be grasped and pulled about by the edges when loaded. In making initial tear tests a sample of material is inserted in the two jaws of the instrument and then a constant tearing force is applied by revolving one of the jaws until a tear is started. The force required is measured in "force pounds" and result of test is indicated directly on instrument dial. This new instrument will test insulating papers, news print, roofing felts, liner board, floor coverings, corrugated board, three-ply boxboard, hard fibre, superfibre board, and similar materials. When desired, a stretch indicator, to indicate in degrees the amount of stretch in material before it tears, can be included in this instrument. Dimensions, 22"x9"x19" high. Net weight 75 lbs.



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The "Alnor" Combination Pyrocon

Ideal for rolls, molds, plates, platens and plastic material temperatures.

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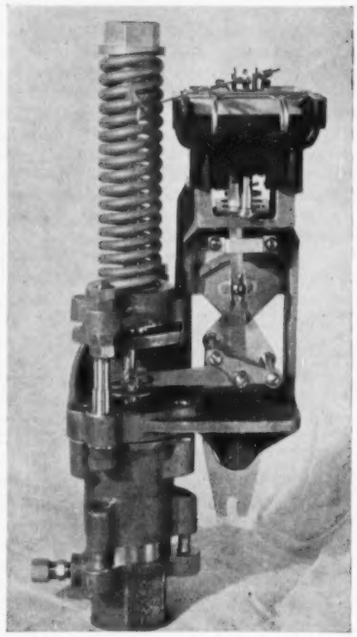
Illinois Testing Laboratories, Inc.

142 W. Austin Ave. Chicago, Illinois

Piston Type Pressure Recorders

The Esterline-Angus Co.

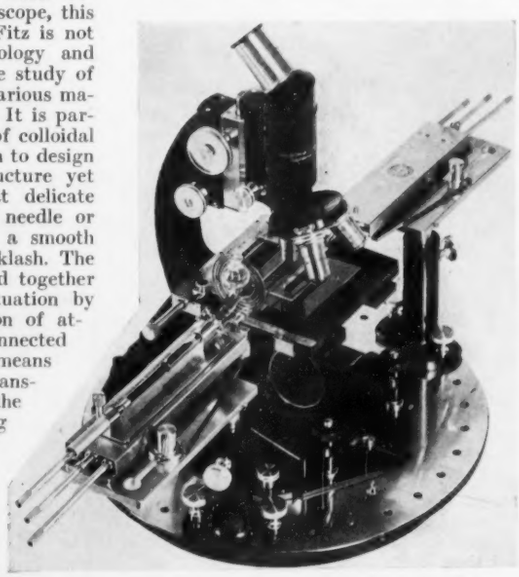
NEW recorder can be supplied for any pressure range from 200 lbs./in.^{2} to as high as 5000 lbs./in.^{2} New design has a wider range of usefulness than any previous model; can be supplied with a self-contained contact-making feature. Spring loaded piston, similar in principle to a steam engine indicator, is capable of withstanding sudden or constantly changing pressures, as on penstock surge tests, water hammer measurements, hydraulic pipe testing, measurements at outlet of reciprocating pumps or in certain chemical processes, etc. It consists of a cast bronze cylinder with a Monel metal piston, the two lapped to such a fit that leakage is negligible at 5000 lbs./in.^{2} Piston acts against a helical compression spring. Connection between piston and pen staff is through linkage and rack and pinion designed to withstand severe use. Cylinder and piston can be removed for cleaning without affecting calibration, and without necessity of removing instrument from mounting. Recorder can also be equipped with an external motor drive and quick trip attachment. This may be combined with the electrical contact-making mechanism, thereby producing a self-contained unit for automatic operation and eliminating necessity for an external pressure switch to operate the quick trip device. These instruments, supplied only in wall mounting cases, can be fitted with rapid feed clocks, motor drives and other standard accessories, including right hand chronograph pens.



Fitz Micro-Manipulator

Bausch & Lomb Optical Co.

FOR handling, manipulating, isolating, dissecting and operating upon microscopic objects such as cells, bacteria, bits of various materials, and other objects in the field of the microscope, this new invention of Dr. G. W. Fitz is not confined to the fields of biology and physiology but is useful in the study of small specks or particles of various materials in microchemical work. It is particularly effective in the field of colloidal chemistry. The object has been to design an instrument simple in structure yet efficient in operation so that delicate movements of the operating needle or pipette can be effected with a smooth steady motion, free from backlash. The adjusting handles are grouped together for instant selection and actuation by the fingers without distraction of attention, and they are all connected to the actuating members by means of flexible coil springs which transmit the motion applied to the handles but eliminate jarring of the manipulator. Another object has been achieved in providing a pair of micro-manipulator units adapted for use, respectively, on the right and left hand sides of a microscope, with the operating handles so arranged that when the tops of corresponding handles of each unit are moved in the same direction (relative to the operator) the respective needles or pipettes will have the same *apparent* motion in the field of the microscope, thus producing "natural" or expected movement. This is accomplished by a unique differential screw system: the unit on the right hand side having a screw provided with left hand threads and the unit on the left hand side having a screw provided with right hand threads. The improved syringe offers a convenient and easily operated means for injecting or aspirating gross or minute amounts of material. Drops of fluid containing minute organisms can be rapidly searched and the desired organisms isolated and separated from the fluid by accurately controlled suction. The two pillars which support the manipulator units may be placed in any of the holes near the periphery of the base, permitting attack of the specimen from any desired azimuth.



Marine Type Electrical Resistance Thermometer

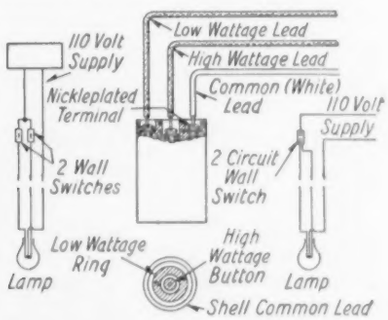
Thwing Instrument Company

BUILT to withstand possible submersion in sea water, this unit embodies the idea put forward by Thwing engineers of putting the indicating galvanometer and the bridge, the selector dial switch, the battery, and in fact, the complete apparatus in one waterproof case. It consists of a horizontal edgewise indicator and a 24-point double-pole rotary dial switch; and, just under the switch compartment, a junction box and battery compartment. Leads from thermometer bulbs are brought into bottom of case through water-tight terminals and stuffing tubes. All galvanometer parts are specially treated for rust-proofness; aluminum outer case of special government mixture is anodized before painting. Galvanometer is specially damped to withstand changes of angle and rolling and pitching. It is of the direct-deflection type, magnetically shielded and scaled directly in temperature. No "balancing" is needed to take temperature readings. Current supply is an ordinary dry cell located in a special compartment in the lower part of the case. Rheostat is at right side of case, brought out through waterproof stuffing boxes, as is the outside zero adjuster. Said to be a unique arrangement, the galvanometer control switch seen at the left reduces the swings of the needle, and also reduces battery deterioration. Dimensions, 17⅜" × 7½" × 9½".

Three-circuit Socket

Westinghouse Elec. & Mfg. Co.

FOR applications requiring two or three intensitives from the same lighting unit, this new 3-circuit lamp socket, especially adaptable for the new 3-light lamps, is similar in outward appearance to the present mogul porcelain socket but the interior has been redesigned to provide for the high-wattage lead a floating center contact supported by a coiled steel spring; and a ring contact for the low-wattage lead, while the standard shell provides the common lead. In deep cavities on the back are large binding head screw terminals, the screw shell terminal being nickel-plated to denote polarity. Supporting screw spacings are standard.



"Laboratory Type" Microscope for Amateurs

Bausch & Lomb Optical Co.

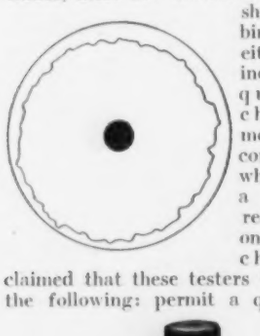
THOUGH designed for beginners, the new Model R follows the design of higher priced instruments intended for serious laboratory and clinical work.

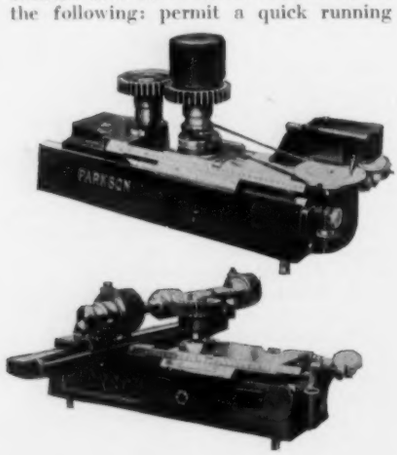
It is of impressive size with an arm stage and base of molded black Bakelite and chromium finished body tube. Magnifications of 75 to 300 X are indicated on the draw-tube. Optical elements are of high-order workmanship. Base is removable for examination of large objects and may be assembled in a horizontal position for micro projection, etc. Mirror of illumination system may be placed either under the stage for transillumination of transparent or translucent objects, or above the stage for illumination of opaque objects. Rack and pinion mechanism is smooth in operation, allowing accurate adjustment for focus even at the highest power of 300 X, and the weighted base with its low center of gravity gives stability.

Parkson Gear Testing and Charting Machines

George Scherr Co.

USED either for final inspection of finished gears or to verify the correct set-up of gear cutting machines, these new testers are designed to show the combined errors either by a dial indicator for a quick visible check or by means of a recording device which furnishes a permanent red-ink record on a circular chart. It is claimed that these testers will do all of the following: permit a quick running test by "feel"; determine accurate center distance instantly by self-adjusting scale and vernier; indicate run-out, tooth jump, etc., visibly on a dial indicator in 0.0005"; or chart a circular graph of the combined errors, 50 times magnified, from which individual errors can be analyzed; measure diameter and check run-out of blank before cutting; not only on spur and spiral, but on bevel gears and worm wheels as well, from 1" to 36" center distance. Gears are tested either in pairs or against a master. They are mounted on stationary arbors held in one adjustable carriage, which can be clamped in position and in a floating carriage, rolling on three steel balls under slight spring pressure. When rotating the gears, the "floating" carriage transmits its movement either to a dial indicator or to a circular recording device.

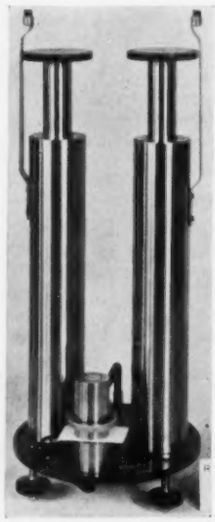




Paper Smoothness Tester

W. & L. E. Gurley

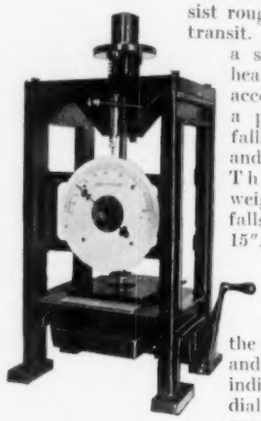
MECHANICAL measurements of paper smoothness are made with this new instrument, in units of surface-porosity — the rate at which air flows through inequalities in the surface — a property different from "gloss" which is an optical characteristic. The "R. D. No. 4160" Smoothness Tester consists essentially of two circular blocks, each having a cross-sectional contact area of 1 in.², lapped and polished optically flat. The sample is placed between them and is subjected to a pressure of 0.5 lb. weight by the top block. It also is centrally subjected to an air pressure of 12" water, equal on both sides. The time (in seconds) for a 5 cc. outward air leak between paper and either block is taken as a measure of the inequalities of the sample, and indicates the "finish." The means for developing air pressure consists of two identical cylinders, containing mercury, in which are floated two bells. These bells have 5 cc. graduations, so that the time may be measured for known air flows. Average results from tests on ten samples should be obtained for each grade of paper. Constant humidity conditions are preferable. Analagous results are said to be obtained with duplicate instruments, because block surfaces are tested against an optical flat and then against each other to show no air leakage, bells are identical in diameter and weight, and entire construction is precision work. The following advantages are claimed: (1) both wire and felt sides measured at same time; (2) low unit pressure applied to sample causes no change in its finish; (3) portability; (4) easy operation; (5) short testing period. *Specifications:* Height, 12¾"; extended, 16¾". Diameter of base, 6½".



Impact Tester

Thwing Instrument Co.

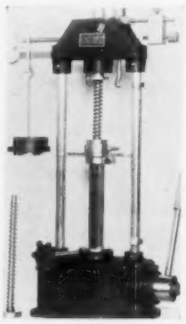
MEASURING resistance to sudden impacts of sharp objects, the Thwing Impact Tester is used for testing boxboard such as used for containers which must resist rough handling in transit. The effect of a sudden and heavy impact is accomplished by a plunger which falls on the board and punctures it. The plunger weighs 6 lbs. and falls a distance of 15". The resistance of the board is directly proportional to the work done and this result is indicated on the dial graduated in gram-meters. The capacity of the instrument is 90 gram-meters. When making a test the specimen is placed in position and held by a weighted platen so that it is always held under a uniform pressure. The pointer is provided with a friction spring which causes it to come to rest at the position corresponding to the point where the motion of the plunger was stopped. Gravity operation assures permanence of calibration. Dimensions 14"x12"x38" high. Net weight 150 lbs.



Compression Spring Tester

Coats Machine Tool Co.

FOR testing slender compression springs which must be supported around a mandrel to prevent buckling, the standard R-80 "Elasticometer" Spring Tester was recently redesigned to allow for the passage of mandrels up to 0.600" dia. The ratio of the beam remains at 10 : 1. For testing long, thin compression springs, it has been found advisable to reduce the clearance between steel balls and compression plate to the absolute minimum, consistent with frictionless passage of the plate, and further to provide for a three-point ball contact between bore of upper compression plate and mandrel. This latter arrangement centers the mandrel within the bore of the compression plate and here again the steel balls are free to move vertically. As the bore of compression springs increases under load, it is impossible to prevent "snakiness" of the spring around the mandrel. Experience has proved that a skin-hardened, highly polished mandrel of the right diameter will greatly reduce friction between mandrel and spring and thus reduce interference with free play of scale beam. Pillars may be extended to accommodate springs 25" long. Maximum load capacity is 175 lbs. but this may be increased to 300 lbs.



"Flo-Trol" Control Valve

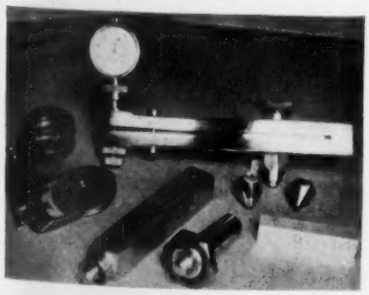
Carrick Engineering Co.

PRIMARILY designed for control of steam, the new "Type FT 1" valve is suitable for oil, gas, air and other fluids. *Adjustability*: The outstanding new feature is that changes of ratios and other adjustments can be made manually while the valve is in service. *Operation* is by any straight-line motion servo motor, etc. *Specifications*: Moving plug type. Body and external parts (except lever) of cast hard bronze for ordinary steam pressures and temperatures. For high steam pressures and temperatures body and head flange of cast steel. Other external parts of gray cast iron. Operating lever always of Monel and stem of stainless steel. *Design*: Steam passing through valve does not come into contact with valve seats, therefore no wire-drawing.

Portable Brinell Tester

The R. Y. Ferner Co.

THREE sizes of steel balls, and the use of different pressures, make it possible with this new Brinell press to measure the hardness not only of steels, etc., but also of lead, copper, etc. Designated as Type M 60/750 (figures denote range of pressures in kg.), it consists of a tapered piece of steel 7" long, slit to within ¾" of the large end. On one side of the large end is inserted a holder for steel balls 10 mm., 5 mm. and 2.5 mm. diameter. On the opposite side may be inserted any of three threaded holders: one for using instrument in a vise or arbor press, the second for using it in a drill press, the third for insertion in the tool post of a lathe, to make tests on work being turned. In the lower prong, at the small end, is mounted an adjustable screw which can be locked; in the upper prong, a small dial indicator which can easily be read to 0.001 mm. and has >3 mm. movement. *Operation*: Adjustable screw is set against contact plunger of dial indicator to read zero with no load applied, and is then locked. Then steel ball in opposite end is placed against specimen, in vise, drill press or lathe, and pressure applied until dial indicator reads position given by a chart furnished with instrument. Ratio of readings to load increments is practically linear: 0.0018 mm. per kg. Press contains a device to prevent overloads $>10\%$. For reading ball impression diameter a special magnifier is supplied with outfit, having a cam-shaped dial which is rotated to obtain diameter, and also shows corresponding Brinell number for 750-kg. load when using the 5-mm. ball. Dial has also a scale of tensile strength of steel in lbs./in.^{2} corresponding to Brinell readings. Brinell numbers for other loads and other ball diameters are found in a book of tables that comes with outfit, which includes also a standard steel test piece bearing an impression and its value.



Short-period Torsion Balance

American Askania Corp.

FAST and economical surveys can now be made with this new balance, lighter and more compact than previous types. It consists mainly of two inclined balance beams (hung up through a torsion wire on a new type torsion head and reversed against each other through 180°) which in their respective tubes have been mounted to a central cast-aluminum casing containing the optical equipment of the instrument. The period of observation is 20 minutes only. All mirrors are easily accessible; so are the balance beams which, through glass windows in the inner aluminum tubes, can be checked visually in their full length. The plate clock used in other types of Askania torsion balances has been eliminated, the displacement of the dots on the photographic plate being possible through rotatable mirrors coupled with the rotation of the instrument. The new balance fits on any later type clock section and bell-shaped base of Askania torsion balances, and can be operated with full automatic recording or semi-automatically by hand. Since the height is about 4 ft. (c.g. at 70 cm.), the new balance can be set up in much smaller field huts and be operated by one-man parties, the weight being 85 lbs. for full automatic operation and 55 lbs. for semi-automatic. As to economy, it is claimed that a station can be covered in 80 minutes, with four dots on the plate (three azimuths and one check). Sensitivity is slightly lower than that of the Askania Z-bar torsion balance. *Constants*:

Upper mass of beam	40.0	g.
Lower mass of beam	40.0	g.
Difference in height of c.g. of the masses	30.0	cm.
Distance, c.g. of masses from c.r. of beam	10.0	cm.
Torsional coefficient of wire	1.2	cgs.
Focal distance of lens	75.0	cm.
Moment of inertia of beam	9035	gcm.^{2}
Sensitivity	1.5	Eötvös

White Water Sampler

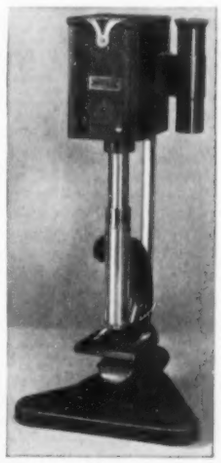
Thwing Instrument Co.

TO be worth the effort and expense of installing it, a White Water Sampler in the paper mill or other industry, or sewerage plant, must meet two conditions: it must deliver a sample that is exactly proportional to the flow; and it must always deliver the samples. This new instrument was developed to meet these conditions. A graduated orifice automatically takes a sample in direct proportion to the flow. It is said that this arrangement cannot get out of order. Moving parts are enclosed. No parts can become clogged. The electric motor drive being contained in the upper part, the top of the casing may be supplied with a window through which a revolution counter can be observed so that the sampler can be used as a flowmeter. Streamline guard prevents foreign matter interfering with collection of samples. All metal parts subject to immersion are non-corrosive. Operating compartment, it is said, could stand months of immersion without damage. Instrument is set on its own permanent location and requires no auxiliary equipment other than a receptacle for holding samples collected. It is supported by two rods, one hinged so that at any time the sampler can be swung out of the current and examined.

Photomicrographic Outfit

Bausch & Lomb Optical Co.

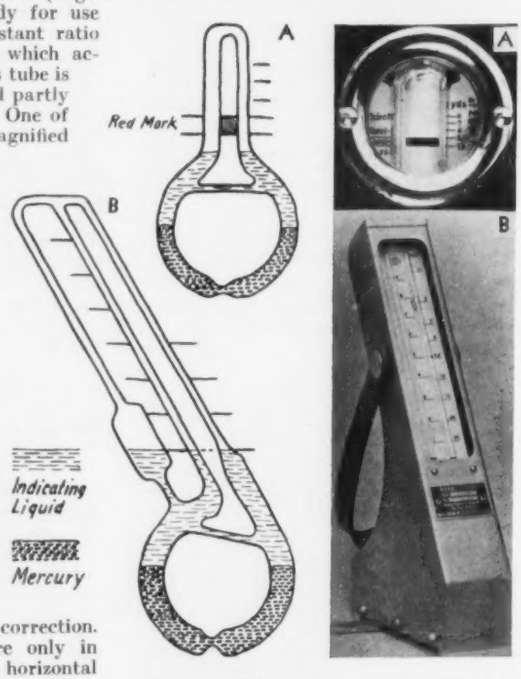
DEVELOPED especially for the amateur, this outfit and the accompanying complete instruction booklet make it possible for him to photograph microscopic specimens as easily and as inexpensively as to make a snapshot. All he need to do is to focus the microscope in the customary way. When the image is properly focused in the ground glass, the camera is swung over the microscope and the shutter snapped. Ordinary Eastman No. 127 roll film is used. The instruction booklet (a notable advance in the literature of amateur microscopy) is the only thing of its kind written especially for the beginner. It tells how to set up the outfit, adjust illumination (an important factor), test for the most exact illumination and secure the best focus; and covers the use of filters, films, and the results of exposures and magnification. The chapter on development and printing of films shows how, with simple equipment, a kitchen or basement may be made to serve as a workroom.



Brake Testers

Herman H. Sticht & Co.

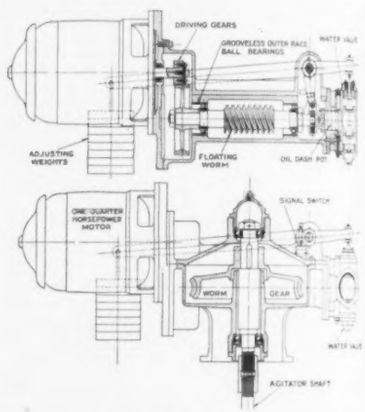
TWO new instruments, operating on liquid pendulum principle, are announced for measuring deceleration of cars, trucks and buses on application of brakes. *Instrument Board Model* (Figs. A, A) is simple, always ready for use and claimed to possess a constant ratio of friction and damping, on which accuracy depends. Circular glass tube is partly filled with mercury and partly with a black indicating liquid. One of vertical tubes above gives a magnified indication of the movements of the mercury. Damping is provided by a contraction of the glass tube in the mercury portion. A capillary joining the two vertical tubes is sufficiently narrow to be ineffective during braking but permits liquid to return to zero in both arms, even when pendulum is not exactly vertical. Liquid column in right hand vertical tube indicates the braking effect: if, on applying brakes, it remains below red mark, brakes are not operating satisfactorily. The scale at the right of the vertical tube indicates "the distance in braking yards." based on initial speed of 20 m.p.h. Left-hand vertical tube has greater diameter, thus effecting temperature correction. Use is simple, requiring care only in making test on smooth and horizontal stretch of road. *Portable Model* (Figs. B, B) is of generally similar design but has a "temperature equalization" chamber of large cross-sectional area and an additional tube for measuring acceleration. In order to ensure stability during severe braking operations the center of gravity is low. To prevent instrument falling sideways, arms are fitted to base, which can be swivelled outwards. To make tests, instrument is simply placed on the floor in the direction of motion. Brakes should be applied long enough to allow liquid pendulum to remain at its maximum deflection. Minimum speed for this is around 15 m.p.h. Black liquid remains stationary long enough for its position to be read off. Scale along vertical tubes can be marked in yards/sec.² and also, if desired, in the "braking distance" for a definite initial speed. The second tube indicates acceleration: it serves the purpose of testing pick-up "provided the conditions of starting are equal and one is thoroughly acquainted with the car. If desired, this vertical tube can also be marked in yards/sec.², so that the liquid pendulum is permitted to attain its maximum deflection."



Consistency Regulator

Merritt Engineering & Sales Co.

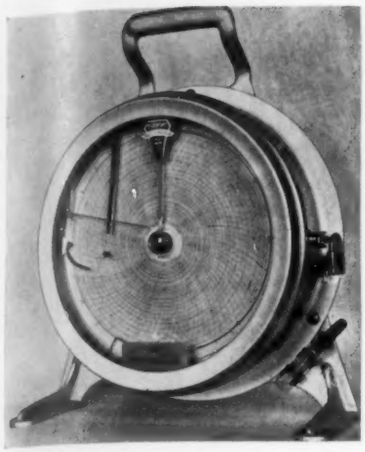
FULLY automatic control of the consistency or viscosity of process mixtures (such as the stock in a paper stuff-box just ahead of the machine screens) is achieved by the new Model "V" Precision Meyers-Mesco Regulator. *Operation* (refer to both sectional views): A paddle-like agitator (not shown) is driven at 30 r.p.m. in a clockwise direction. Rotation is imparted by a fully enclosed triple thread worm and gear. The worm is carried upon ball bearings having grooveless outer races, thus allowing it to shift lengthwise. Movement of worm is transmitted to balanced water valve through simple levers, and is limited by the adjusting weights. If stock becomes heavy, increased worm thrust causes worm to shift to left raising weights and opening valve. Lighter stock causes an opposite action. Regulator is equipped with an oil dash pot at right hand end of worm shaft to dampen any tendency to hunt due to oversensitiveness. Machine is driven through finely cut spur gears by a ¾ h.p. repulsion induction motor. A signal lamp lights just before valve reaches the closed position, warning those in charge of stock preparation that stock is initially light and must be made heavier. Under normal operation, signal should not show. Regulator is furnished complete with a substantial wood stuff box having a precision type "V" port gate. Each compartment is proportioned to suit the volume of stock to be handled. Only that part of the stock actually being used is regulated, and chest capacity is maintained because regulating water is not admitted to overflow stock. Water from regulator valve meets stock at the bottom of box as it enters agitator chamber. Here water and stock are vigorously mixed, lumps broken up, and machine has plenty of time to "feed" the density and correct it if higher or heavier than the density for which the machine is set. Regulator is adjusted to any density within its range by adding to or taking away weight from the counterweight lever.



Höppler Viscosimeter

Dr. F. A. J. Zeidler

IN the most frequently used range (10 to 600 centipoises at 20°C.) the original model of this absolute viscosimeter was found by the Physicalisch-technische Reichsanstalt to have an error of ±0.1%, and on the whole to be the most accurate "of all viscosimeters ever tested in this institution" (report dated June 1933). *Principle:* The Höppler Viscosimeter depends on the eccentric descent of balls of various sizes in a closed column of liquid. *Models:* The laboratory standard model is constructed to a dimensional precision of ±0.005% and consequently is sufficiently accurate for measuring the viscosities of gases or for determining the difference in viscosity between distilled and tap water. The industrial model is inexpensive and convenient. The simple multiplication of the fall-time with the ball factor taken from the supplied calibration table gives immediately the viscosity of the investigated liquid in centipoises, with an accuracy of $<\pm 0.75\%$. All viscosities can be measured indeed, from the lightest petroleum ether to barely fluid tar, at 20°C. and also at higher temperatures. This measuring range exceeds those of the present viscosimeters. This instrument is especially suitable for the investigation of dark and opaque liquids. With a single filling (30 cm.³) and without transfer, viscosity-temperature curves can be drawn through many points in about $\frac{1}{10}$th the time necessary when using the efflux type. Until the absolute system is universally accepted, tables are supplied for converting absolute degrees to Engler degrees. When desired, the standardization can be carried out by the Physikalisch-technische Reichsanstalt.



Portable Recorders

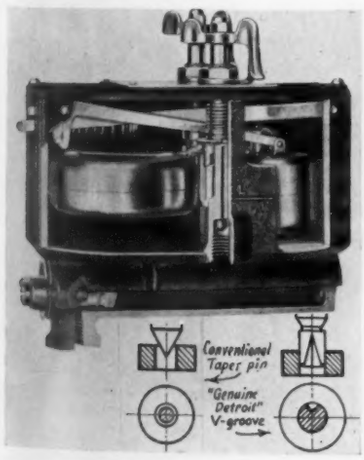
The Foxboro Co.

NOVEL design ideas make for convenience in carrying, using and adjusting these new 8" and 10" size portable temperature and pressure recorders: Instrument hangs naturally when carried and grip "feels right" because handle is in same vertical plane as center of gravity. When instrument is set down on a bench or desk, door can be swung out without disturbing stability of equilibrium. Charts are changed in a few moments. Chart disk can be removed without using screwdriver and interior becomes accessible in a few seconds. Ink bottle and dropper are carried where they are both handy and well protected. Remote-bulb thermometers are available as well as self-contained instruments. By unscrewing three bolts, instrument becomes wall type. Standard finish is frosted silver; others optional.

Safety Float Valve Unit for Oil Burners

Detroit Lubricator Co.

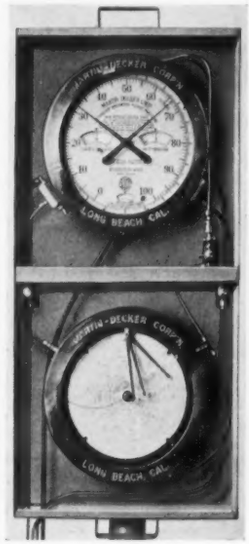
COMBINING a strainer, a constant-level valve, a safety trip mechanism and "vented metering valves" with adjustable maximum stop and graduated dials, the new CRC-234 assembly will maintain fuel delivery constant in spite of variations in fuel supply head due to difference between a full and an empty tank. Strainer has 9 in.² Monel screen area. Safety trip mechanism has been improved so that when it has tripped, needle will resist 90 lbs./in.² pressure under seat. Metering valves are of V-groove design with orifice width approx. 20 times that of conventional taper pin annulus for same area. A priming or spring return feature facilitates quick lighting and permits air to escape on starting.

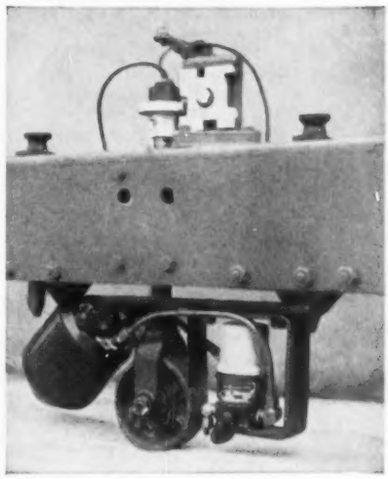


Quintuplex Gage for Well Drilling Control

Martin-Decker Corp.

FIVE measuring systems, recording and/or indicating important conditions which drillers must control manually, terminate centrally on the semi-portable instrument board illustrated, affording for the first time "complete centralized drilling control." *1 & 2. Weight:* Diaphragm-type transmitter installed on dead line is an improved model of those described in these columns (Oct. 1931, page 561; March 1933, page 61), employing a non-freezing transmitting fluid (supplied in cans) having a definite temperature coefficient of expansion for which compensators are adjusted permanently. It actuates weight indicator and vernier pointers at center of upper instrument and one of three pens of recorder. *3. Mud Pump Pressure:* Diaphragm-type transmitter, connected to mud line at any convenient point, actuates rotating-dial type indicator (right-hand quadrant on quintuplex) and the second pen of the recorder, by pressure transmission, using same special fluid which permits temperature compensation. *4. Torque:* This element, measuring steam pressure in manifold of drilling engine, has diaphragm transmitter attached to manifold and actuates left-hand quadrant dial on quintuplex and third recording pen on lower instrument. *5. Rotary Table Tachometer* (bottom quadrant dial of upper instrument) has a flexible shaft terminating in a pulley belt-driven from the table or any associated rotating part, and requires only initial calibration by the stop-watch method. *Pulsation Dampers* (see *Instruments*, Oct. 1931, page 572) are supplied on the "mud" and "torque" pressure-transmission systems. The instruments proper (illustrated) are made for the Martin-Decker Corp. by the U. S. Gauge Co. In the quintuplex, each of the five units can be removed without disturbing the others; the 3-pen recorder uses a 3-zone chart so that no two pens can interfere, and any of its three pressure-tubes can be removed without disturbing the others.





Solenoid Valve Marks High and Low Spots in New Roads

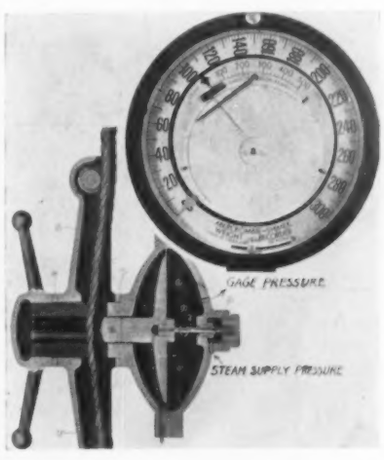
General Electric Co.

A UNIQUE application of a normally-closed solenoid-operated valve has been made on a road surface tester which locates high spots and depressions. This tester (H. and H. Mfg. Co., Elyria, Ohio) consists of a framework on wheels on which is mounted a free-moving roller with an extension arm which follows the road profile independently of the truck wheels. Upper part of extension arm makes a contact if roller moves in either direction beyond permissible limits. Whenever this contact is made, the G-E solenoid valve mounted on the frame is energized, opens, and squirts marking fluid on the high or low spot. The same contact flashes a signal lamp.

Triplex Gage for Well Drilling Control

Cameron Iron Works

SEVERAL features of this new Abercrombie-Shimek Weight Recorder, by reason of their unique combination, go to make a stress-determining system which is unaffected by temperature changes, by small leaks or



by small amounts of air in the system; which indicates load on hook directly in thousands of pounds; which has a straight-line calibration curve, and which is said to be easily installed and serviced. *Principle:* Force due to load, on one side of diaphragm, is automatically balanced by fluid pressure on other side. Sectional view shows inlet valve and outlet valve closed and diaphragm in null position corresponding to constant load on hook. Assume load is increased: diaphragm will be displaced, carrying outlet valve and its seat and opening inlet valve (seat of which is stationary) thus allowing fluid under steam line pressure to flow into space back of diaphragm. As pressure in back space builds up, diaphragm moves allowing inlet valve to close and stopping rise of fluid pressure at null point. Assume load is decreased: actions of inlet and outlet valves are reversed until balance is re-established. In either case, and at all times, balancing fluid pressure is transmitted to instrument. Since diaphragm always returns to null position, angle in line remains constant and calibration curve is linear, allowing instrument to indicate accurately regardless of cable arrangement or cable size. *Instruments:* Triplex gage unit (illustrated) indicates load and steam pressure and records load on a 10" chart; duplex unit has no recorder. All load-measuring elements have compensations for water head, block weight, etc.

Insulation Tester

Sound Engineering Corp.

DIELECTRIC strength test hazards, and the technical difficulties of accurately measuring voltage at the point of breakdown, make necessary highly specialized apparatus, incorporating the following features: (1) absolute safety to the operator, (2) accuracy, (3) smooth, convenient control of voltage from 200 to 10,000 volts or more, (4) definite pressure and even distribution of the electrical field over the test area of the sample, (5) simplicity of operation and rugged construction. The Model 1-IE Dielectric Strength Test Set has been designed and engineered to meet these requirements. *Dimensions:* 19"x18½"x10¼". *Weight:* 65 lbs. *Power Supply:* 110 volts, 60 cycle (220 volts supplied, if required). *Construction:* Completely self-contained in a strong all-metal case. All parts rigidly mounted within the case.

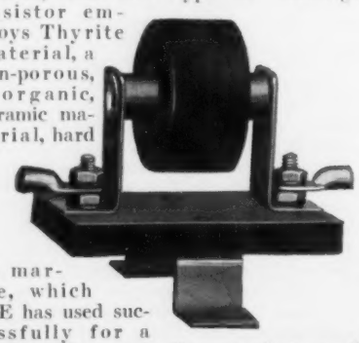
Circuit, etc.: Transformer secondary delivers a maximum potential of 10,000 volts. This winding is grounded at its exact center so that highest potential to ground never exceeds 5000 volts. Work circuit across secondary is also balanced to ground with instrument at center, thus entire movement is substantially at ground potential. A Weston vane type instrument using a 10 ma. field coil is used in conjunction with 2 sets of resistors to measure voltage across test sample. It is calibrated in 3 ranges, 0-1000, 0-5000 and 0-10,000 volts. Smooth, gradual control of voltage is obtained by means of a large rheostat wound with nichrome wire, suitably tapered, its slider driven by a helical screw for fine adjustment of voltage. Electrodes are chromium plated brass curving away from test sample to distribute the field and prevent edge effects and brushing. Upper electrode connection to source of potential is through a light spring brush so that it is substantially free and exerts a definite mechanical pressure on the sample. Size and weight of electrodes are in exact accord with A.S.T.M. specifications. *Safety:* (1) Primary circuit of transformer is broken by means of a switch connected mechanically to cover of instrument so that high voltage is cut off as soon as cover is raised even slightly. (2) A bright warning light flashes as soon as high voltage circuit is energized. (3) Unit is completely self-contained in a grounded metal case.

Uses: Particularly the testing of sheet material. Instrument is provided with slots so that a long tape may be inserted and tested at several points. It can also be used for testing manufactured products which are required to stand high voltages. For insulated wire, narrow tape, etc., special electrodes can be supplied. Higher voltages or other modifications of the unit may be furnished..

Thyrite Discharge Resistors

General Electric Co.

TO protect insulation of d.-c. magnetic circuits against excessive discharge voltages when circuits are opened, this new type of discharge resistor employs Thyrite material, a non-porous, inorganic, ceramic material, hard as marble, which G-E has used successfully for a number of years in the manufacture of lightning arresters. Conducting about 16 times more current each time the voltage is doubled, this material is practically an insulator at line voltages, hence reduces the continuous watts loss for the new Thyrite units to approx. 2% of that for equivalent permanently-connected fixed resistors. Type CR9196 Thyrite Discharge Resistors are available in two ratings—one for 110 to 275 volts; the other for 500 to 650 volts. They can be conveniently applied to protect d.-c. motor fields, lifting magnets, shunt fields of a.-c. and d.-c. generators, etc.



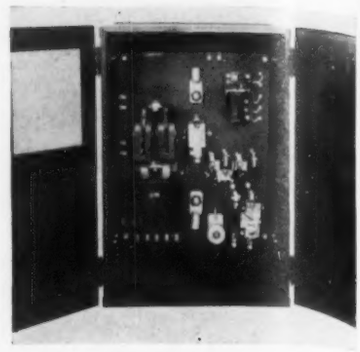


Fig. 1

Automatic Arc-welding Head and Control

General Electric Co.

SIMPLICITY of design, control, adjustment to work, and maintenance is said to characterize this new Type WFA automatic arc-welding head operating from 60-volt d.c. supply. One small motor drives the electrode feed rollers through a simple worm reduction gear and 3-speed transmission. At any of the three speeds, selected to suit electrode size, current, and rate of deposition of metal, the electrode is fed at a uniform rate and the arc voltage is automatically maintained. One small rheostat being the only adjusting element necessary, control of the electrode feed is quick and accurate as all other operations are fully automatic. Handwheels swing the nozzle through complete circles in two planes at right angles to each other, permitting universal motion of head and facilitating following an irregular outline. Electric control equipment consists of an enclosed panel approx. 3 ft. high (Fig. 1) on which are mounted standard G-E relays and contactors which maintain in proper sequence the operations necessary in starting, running, and stopping the automatic arc-welding head; and of an instrument panel (Fig. 2) which may be located anywhere but preferably is placed as close to the welding position as possible. Panel carries instruments reading arc voltage and current, arc voltage adjusting rheostat, start-stop buttons, forward-reverse switch for electrode feed mechanism, and a selector switch for either manual or automatic operation of a travel carriage if the latter is used.

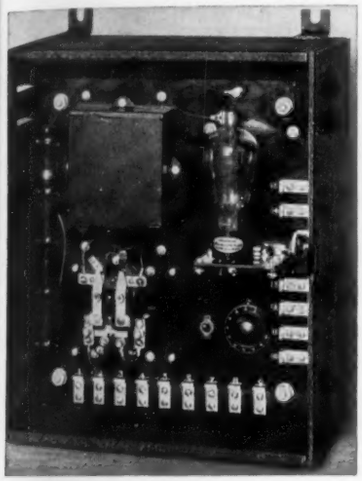
Fig. 2

High-speed Photoelectric "Lock-in" Controllers

Westinghouse Elec. & Mfg. Co.

INDUSTRIAL control devices for initiating a control function from an actuating impulse as brief as 1/5000 sec. are announced. The impulse may be a minute current or voltage received from a phototube, delicate contacts, control circuits, or similar sources where the impulse is too small or too brief to actuate directly the usual type of relay. Equipments are available which will maintain the response indefinitely or for an adjustable predetermined length of time. Significant data on these new "Photo-Trollers" are given in the adjoining table.

The RR-0 Photo-Troller, simplest of the group, uses a single grid-glow tube to operate a contactor, solenoid, or similar device. Either an increase or decrease in illumination may be utilized. Rectox units are employed to supply d.-c. power to input terminals for the phototube, and for the grid-glow tube. Therefore, after

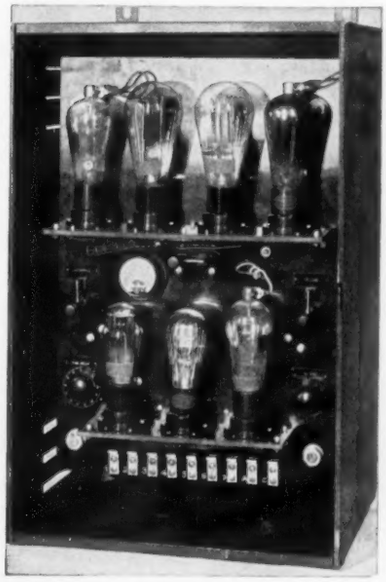


Type RR-0

current passed by the tube begins flowing, it will continue until load circuit is interrupted by an external device such as a limit or cam switch. Maximum number of operations per minute for electronic equipment is 5000.

The RR-1 Photo-Troller uses an amplifier tube and a rectifier tube, making it more sensitive than, but of comparable power, to the RR-0. A modification, type RR-1A, has an additional relay for handling a larger load. The RR-1A may be operated 1000 times per minute.

The RR-3 unit features higher power relays and an electronic time delay circuit adjustable between 0.1 and 2 seconds for automatically interrupting the current of either of two grid-glow tubes. Can be set up to perform special sequence control operations in connection with a mechanical synchronizing device for selective operation of relays in accordance with relative position of objects and indicating media; example, controlling position of printed paper with relation to cutters for making paper bags. Normally used where it will not operate more than 25 times per minute, but may be operated up to 150.



Type RR-4

The RR-4 is similar to RR-1 except that output power supplied by two high-current amplifier tubes in parallel is normally flowing and that an entirely electronic time delay feature is added to re-establish the output current in a given time after the control impulse has caused it to stop flowing. No relays or other mechanically moving parts are used so that the equipment will withstand an indefinite number of operations without requiring replacements. Operations per minute depend upon the setting of the time delay circuit and may be as high as 5000.

Each of these Photo-Trollers comprise a panel assembly upon which are mounted the tube sockets, transformers, resistors and other accessory parts enclosed in a crinkle-finish cabinet with several knockouts. Sensitivity adjustments are provided.

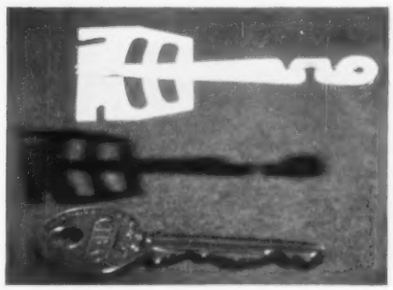
Type	Cycles	Sensitivity: Minimum Duration of Impulse Seconds	Sensitivity: Minimum Illumination Ft.-Cdls.	Rating Per Contact Amps.	Rating Per A.-c. Volts	Power Output* Volts	Power Output* Amps.	Power Consumption Watts
RR-0	50-60	0.001	14	None	...			140
RR-0	25	0.001	14	None	...	100	0.1	140
						60	0.25	
RR-1	25-50-60	0.0002	6	None	...	50	0.5	170
RR-1A	25-50-60	0.0002	6	1.0	110			175
RR-3	25-50-60	0.0002	3	10 5	110 220	...	...	250
RR-4	25-50-60	0.002	6	None	...	135	.3	275

*This full-wave rectified power is available for operating auxiliary relay, solenoid or other device. In equipments with relay included, relay is operated by this power, which may be used directly if relay is not needed.

"Fly-weight" Recording Strain Gage

Baldwin-Southwark Corp.

NO larger than a latch key, the de Forest Scratch Recording Strain Gage weighs two grams yet makes an autographic and permanent record of strain—or displacement—variation. Due to its small mass it may be mounted in positions and places inadmissible to any other type of strain measuring device. For example, records have been secured of the strain variation, including vibration, in an aeroplane propellor blade in flight. The record is scratched by an abrasive—in one o fthe more elaborate types, a diamond—on a strip of chrome-plated brass or on a shard of blued clock-spring steel. The record is actual size and must be evaluated under a microscope—preferably with filar eyepiece—of a magnification of at least 100×. Magnifications up to 1500× are entirely feasible. A measurement, of course, together with a knowledge of the material under strain gives, by a simple calculation, the stress in the fiber under investigation, with an accuracy nearly equal to the accuracy of the knowledge of the elastic modulus of the material. Mounting is simple and depends on conditions. A spot of solder, three No. 4 screws and tapped holes, small clamps are some of the mounting devices. When no transverse strains—such as torsional strain in the presence of longitudinal—are present, the records



are readily interpreted, it is said. In many cases the presence of harmonics superimposed on the strain record is revealed. When such transverse strains are present the interpretation becomes more difficult but the revelation is no less valid and sometimes even more striking.

If anyone should by chance be carrying a weapon when he enters the exhibit of the Electric Light and Power Industry at the Chicago World's Fair, a metal detector will sound or flash an alarm. Similar to that which is being introduced in police departments for the location of concealed weapons upon criminals when they are arrested, this instrument will signal if the person standing before it has any metal concealed about his person, a knife, keys, etc. Industrial plants are beginning to use such metal detectors for inspection. For instance, candy factories have found them invaluable in locating small bits of metal that might be gathered by the mixture during process of manufacture.

LETTERS TO THE EDITOR

Two Sugar Industry Instrumenticians Send Sugary Comments

To the Editor:

In your June issue I noted your group subscription offer. Inasmuch as I have been a subscriber since the first time a copy of *Instruments* came to my notice, it occurred to me that a number of my friends could be equally benefitted by acquaintance with your very splendid magazine, since instrumentation in all its many phases is a subject of vital importance in sugar manufacture.

Accordingly a circular letter was sent out to the chemists or superintendents of most of the Hawaiian sugar plantations, and to date twenty-one have replied. Enclosed you will find my check for $21, together with the list showing post-office addresses . . .

While complete returns are not yet in, it is expected that several more will be received and I presume that it will be satisfactory to add them to the above group-subscription list at the same rate.

E. Brewer & Co. — WALTER E. SMITH
Honolulu, Hawaii — *Technologist*
July 16, 1934

P.S.—While writing the above, one more subscriber has come in, hence the above figures are changed to 22.

To the Editor:

. . . I am a subscriber to *Instruments* and very much pleased with all the information it contains. The descriptions of new instruments and measuring devices are very helpful.

Pennsylvania Sugar Co. — JOSEPH MIHALIK
Philadelphia, Pa. — *Instrument Man*
July 26, 1934

"No Other Like It"

To the Editor:

We find your magazine to be useful in a unique way. Your claim that there is no other publication like it, is well substantiated.

Bell Telephone Laboratories — A. L. JOHNSRUD
New York, N. Y. — *Research Department*
July 10, 1934 — *Equipment Engineer*

"Filing Technical Ideas"

To the Editor:

For one who has followed the work of Lev A. Trofimov, his article in your June issue on "Filing Technical Ideas" is but a natural consequence of what he has already done. He has tried to show us that it is possible to organize our thoughts in a scientific manner in order to reach more effectively the solution of a problem, and now he tells us how to organize the accumulated thought of others in the solution of our future problems.

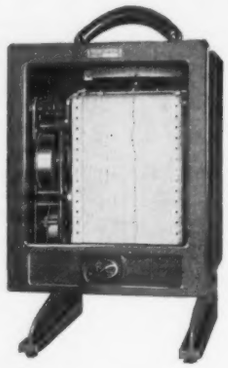
His present article is a challenge to all technical workers. The future author will see that he must give a scientific statement of the problem he sets himself to solve, and of the physical principle upon which he is basing his solution. The editor will see a highly useful criterion for selecting articles, inasmuch as the intelligent reader wants more than a description of the finished product. The reader will see at once what really counts in the article he is reading.

All research workers gain from the results of others but few gain from their mode of thinking. Mr. Trofimov, it seems to me, is opening the way for the latter.

The detailed description of filing according to two main classes, "force" and "substance," has great possibilities. It is bound to be useful in many research laboratories, as the many practical illustrations suggested show. I have tried to think myself through it within my own field of specialization with, of course, different main classes but I did not go far. I am inclined to feel that subjective classification is not always advantageous or even possible in a narrow field, and particularly when the field is of a theoretical nature. Of course the ideal specialist needs no filing system, he knows the literature and its contributors.

However, there is no doubt in my mind that the proposed filing should and will attract the thoughtful attention of heads of laboratories. One also should expect that a trained librarian with technological experience could contribute toward the initial details of such a venture.

Case School of Applied Science — J. J. NASSAU
Cleveland, Ohio — *Professor of Astronomy*
July 23, 1934



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JOHN B. DAVENPORT

The General Radio Company of Cambridge, Massachusetts, announces the opening of an engineering office in New York City at 90 West St. Engineers from the Cambridge staff will be in this office to assist customers in problems pertaining to radio and electrical measurements. Shipments and general-office activities will continue to be handled from the Cambridge office.

The Brown Instrument Company, Philadelphia, Pa., announces the appointment of Mr. L. Morton Morley as General Sales Manager. Mr. Morley will have complete supervision of all sales, advertising, and sales promotional activities. Mr. Morley, former District Manager of the Philadelphia Office, has been associated with The Brown Instrument Company for the past 15 years.

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General Electric Co.
Weston Elec. Inst. Corp.

PHOTO-ELECTRIC COLOR ANALYZERS
General Electric Co.
Thwing Instrument Co.

PHOTO-ELECTRIC COLOR COMPARATORS
General Electric Co.
Thwing Instrument Co.

PHOTOGRAPHIC EXPOSURE METERS
Weston Elec. Inst. Corp.

PHOTOMETERS
Bausch & Lomb Opt. Co.
Gaertner Scientific Corp.

PHOTO-MICROGRAPHIC EQUIPMENT
Rawson Elec. Instru. Co.

PITOT TUBE METERS
George Sidney Binckley
Brown Instrument Co.
Foxboro Co.
Pioneer Instrument Co.

PLANIMETERS
Automatic Flow Record
Brown Instrument Co.
Foxboro Co.
Linear
Brown Instrument Co.
Radial
Bailey Meter Co.
Bristol Company
Foxboro Co.
Square Root
George Sidney Binckley
Foxboro Co.

POLARISCOPES
Gaertner Scientific Corp.

POSITION RECORDERS
Brown Instrument Co.
Bristol Company
Foxboro Co.
Taylor Instrument Cos.

POTENTIOMETERS—
Indicating
Brown Instrument Co.
General Electric Co.
Thwing Instrument Co.
Recording & Controlling
Brown Instrument Co.
Thwing Instrument Co.
Standard Cell Comparing Feussner Type

POWER FACTOR METERS
General Electric Co.
Roller-Smith Co.
Weston Elec. Inst. Corp.

PRESSURE RECORDERS
American Meter Co.
Bailey Meter Co.
George Sidney Binckley
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.

PRISMS
Gaertner Scientific Corp.

PROCESS TIMING & SIGNALING INSTRUMENTS
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.

PROVERS
American Meter Co.

PROTRACTORS
Optical

PSYCHROMETERS
Recording
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.
Sling
Taylor Instrument Cos.

PYRHELIOMETERS—
Weather Bureau Type

PYROMETERS
Optical
Radiation
Indicating
Brown Instrument Co.
Taylor Instrument Cos.
Thwing Instrument Co.
Recording
Brown Instrument Co.
Taylor Instrument Cos.
Thwing Instrument Co.
Thermo-electric
Immersion
Bristol Company
Brown Instrument Co.
Foxboro Co.
Roller-Smith Co.
Taylor Instrument Cos.
Thwing Instrument Co.
Indicating
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.
Thwing Instrument Co.
Recording and Controlling
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.
Thwing Instrument Co.
Surface Contact
Bristol Company
Brown Instrument Co.
Taylor Instrument Cos.
Thwing Instrument Co.

PYROMETER CALIBRATING SETS
Thwing Instrument Co.

RADIO FREQUENCY OSCILLATORS
General Radio Company

RADIO SET ANALYZERS
Weston Elec. Inst. Corp.

RADIO TEST PANELS
Shallcross Mfg. Co.
Weston Elec. Inst. Corp.

RADIO TUBE CHECKERS
General Radio Company
Weston Elec. Inst. Corp.

REFRACTOMETERS

REGULATORS—See Controls

RELAYS
General Electric Co.
Roller-Smith Co.
Ward Leonard Elec. Co.
Weston Elec. Inst. Corp.
Light Sensitive
Burgess Labs., Inc., C. F.
Roller-Smith Co.
Weston Elec. Inst. Corp.
Vacuum Contact
Burgess Labs., Inc., C. F.
Vacuum Tube
Burgess Labs., Inc., C. F.

REMOTE METERING EQUIPMENT
American Meter Co.
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
General Electric Co.
Pioneer Instrument Co.

RESISTORS
General Radio Co.
Roller-Smith Co.
Shallcross Mfg. Co.
Ward Leonard Elec. Co.

RHEOSTATS
General Radio Company
Ward Leonard Elec. Co.

SACCHARIMETERS
Taylor Instrument Cos.

SALINITY INDICATORS

SCALES
Basis Weight
Thwing Instrument Co.
Differential
Thwing Instrument Co.

SEISMOGRAPHS

SHUNT METERS
Bristol Company
Roller-Smith Co.

SHUNTS
Esterline-Angus Co.
General Electric Co.
Rawson Elec. Inst. Co.
Roller-Smith Co.
Weston Elec. Inst. Corp.

SIGNALING DEVICES—
Automatic
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Pioneer Instrument Co.

SMOKE ALARMS
Weston Elec. Inst. Corp.

SPECIAL COILS
Ward Leonard Elec. Co.

SPECIAL ELECTRICAL INSTRUMENTS
Bristol Company
Brown Instrument Co.
General Electric Co.
General Radio Co.
Pioneer Instrument Co.
Rawson Elec. Inst. Co.
Roller-Smith Co.
Shallcross Mfg. Co.
Thwing Instrument Co.
Weston Elec. Inst. Corp.

SPECIAL INSTRUMENTS
Roller-Smith Co.
Thwing Instrument Co.

SPECTROGRAPHS
Bausch & Lomb Opt. Co.

SPECTROMETERS
Bausch & Lomb Opt. Co.
Gaertner Scientific Corp.

SPECTROPHOTOMETERS
Bausch & Lomb Opt. Co.
Gaertner Scientific Corp.

SPECTROSCOPES
Bausch & Lomb Opt. Co.
Gaertner Scientific Corp.

SPEED INDICATORS
See Tachometers

SPEED RECORDERS
Bristol Company
Brown Instrument Co.
Thwing Instrument Co.

SPEED REGULATORS
Ward Leonard Elec. Co.

STANDARD CELLS
Weston Elec. Inst. Corp.

STOP WATCHES

STRAIN GAGES
General Electric Co.

STROBOSCOPES
General Radio Co.

SUNSHINE RECORDERS
Taylor Instrument Cos.

SURGE INDICATORS & RECORDERS
General Electric Co.

SYNCHRONOSCOPES
Weston Elec. Inst. Corp.
Roller-Smith Co.

SYNCHRONIZATION FORKS
Electrical
General Radio Co.

SYNCHRONOUS MOTORS
General Electric Co.
Pioneer Instrument Co.

TACHOMETERS
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Pioneer Instrument Co.
Roller-Smith Co.
Thwing Instrument Co.
Weston Elec. Inst. Corp.

TACHOSCOPES
Brown Instrument Co.

TELEMETERS—See Remote Metering

TELESCOPES
Bausch & Lomb Opt. Co.
Gaertner Scientific Corp.

TENSOMETER (Huggenberger)

TESTING MACHINES
Thwing Instrument Co.
Fatigue
Impact
Impact (very light load)
Thwing Instrument Co.
Hardness
Oil & Bearing
Paper
Thwing Instrument Co.
Penetration
Thwing Instrument Co.
Portable—Tensile—Compression
Sheet Metal
Stiffness & Bending
Thwing Instrument Co.
Stretch
Thwing Instrument Co.
Tearing
Thwing Instrument Co.
Tensile (very light load)
Thwing Instrument Co.
Universal

THERMIONIC RECTIFIERS
General Electric Co.

THERMO-JUNCTIONS (Electric)
General Radio Co.
Rawson Elec. Inst. Co.
Roller-Smith Co.

THERMO-VOLTMETERS, AMMETERS
General Radio Company
Rawson Elec. Inst. Co.
Roller-Smith Co.
Weston Elec. Inst. Corp.

THERMOPILES

THERMOMETERS
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Gas Filled
Foxboro Co.
Taylor Inst. Companies
Mechanical
Brown Instrument Co.
Foxboro Co.
Mercurial
Bristol Company
Taylor Instrument Cos.
Resistance
Brown Instrument Co.
Foxboro Co.
Thwing Instrument Co.
Vapor-Tension
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Inst. Companies
Wet & Dry Bulb
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.
Thwing Instrument Co.

THERMOSTATS
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.

THERMOSTATIC BIMETAL
W. M. Chace Valve Co.

TIME INDICATORS

TIME METERS
General Electric Co.
Weston Elec. Inst. Corp.

TIME OPERATION RECORDERS
Bristol Company
Foxboro Co.

TIME RECORDERS
Bristol Company
Brown Instrument Co.
Foxboro Co.

TIME SWITCHES
General Electric Co.

TIMERS
Rawson Elec. Inst. Co.

TIMING DEVICES
General Electric Co.

TORSIOGRAPH

TOTALIZING INSTRUMENTS
American Meter Co.
General Electric Co.

TOTALIZING RELAYS
Electric
General Electric Co.

TRANSFORMATION POINT RECORDERS
Brown Instrument Co.

TRANSFORMERS (Instrument)
General Electric Co.
General Radio Co.
Roller-Smith Co.
Weston Elec. Inst., Corp.

TRANSITS
Astronomical
Gaertner Scientific Corp.
Pocket
Taylor Instrument Cos.

TUNING FORKS—
Electrically Driven
General Electric Co.
General Radio Co.
Gaertner Scientific Corp.

TURBIDIMETERS
Bausch & Lomb Opt. Co.

U-TUBE MANOMETERS
Bailey Meter Co.
Brown Instrument Co.
Taylor Instrument Cos.

VACUUM RECORDERS
Bailey Meter Co.
George Sidney Binckley
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.

VACUUM TUBE BRIDGES
General Radio Company

VACUUM TUBE RELAYS
Burgess Labs., Inc., C. F.

VACUUM TUBE VOLTMETERS
General Electric Co.
General Radio Co.
Rawson Elec. Inst. Co.

VALVES
Automatic Shut-Off
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.
Back Pressure
American Meter Co.
Balanced
Bailey Meter Co.
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.
Blow-off
American Meter Co.
Diaphragm
Bristol Company
Foxboro Co.
Taylor Instrument Cos.
Differential
American Meter Co.
Electrically Operated
Bristol Company
Brown Instrument Co.
General Electric Co.
Taylor Instrument Cos.
Meter Operated
Bristol Co.
Pressure Relief
American Meter Co.
Proportional Air-Gas
American Meter Co.
Reducing
Bailey Meter Co.
Taylor Instrument Cos.
Regulating
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.

VENTURI METERS
Bailey Meter Co.
George Sidney Binckley
Brown Instrument Co.
Foxboro Co.
Pioneer Instrument Co.

VIBROGRAPHS

VIBROSCOPES

VISCOSIMETERS
George Sidney Binckley
Taylor Inst. Companies

VOLTAGE DIVIDERS
General Radio Co.
Ward Leonard Elec. Co.

VOLT-AMMETERS
General Electric Co.
Roller-Smith Co.
Weston Elec. Inst. Corp.

VOLTMETERS
Electrostatic
General Electric Co.
Rawson Elec. Inst. Co.
Roller-Smith Co.
Indicating
General Electric Co.
General Radio Co.
Rawson Elec. Instru. Co.
Roller-Smith Co.
Weston Elec. Inst. Corp.
Recording
Bristol Company
General Electric Co.
Roller-Smith Co.
Thermionic Rectifier
General Radio Co.

WATER METERS
Bailey Meter Co.
George Sidney Binckley
Brown Instrument Co.
Foxboro Co.

WATTHOUR METERS
General Electric Co.

WATTMETERS
Indicating
General Electric Co.
Rawson Elec. Inst. Co.
Roller-Smith Co.
Weston Elec. Inst. Corp.
Recording
Bristol Company
General Electric Co.
Roller-Smith Co.

WAVEMETERS
General Radio Co.

X-RAY SPECTROMETERS
Bausch & Lomb Opt. Co.
Gaertner Scientific Corp.

The Franklin Institute announces the award of a John Price Wetherill Medal to Dr. J. E. Shrader of Drexel Institute, Philadelphia, "in consideration of the design and construction of a portable and easily operated instrument for the investigation of vibrations, which affords simultaneous records of vibrations in three mutually rectangular directions and in which the inventor displayed much ingenuity."

This instrument was originally designed for the investigation of vibrations in turbogenerators, but has proven suitable for such applications as: Vibrations in Diesel engines, electric motors and generators, vibrations of foundations, and of buildings, testing suitability of absorbers for the isolation of machinery to prevent vibration.

James T. Adams, a graduate of the Massachusetts Institute of Technology, and formerly with the General Electric Company, is now a sales correspondent, to assist in handling engineering problems for Struthers Dunn customers.

Paul Kammerer, 65, founder of the Pittsburg Instrument & Machine Co., died on May 14 after a short illness. Mr. Kammerer started the company 35 years ago and was active until his death. Before that he was in the experimental department of the Westinghouse Elec. & Mfg. Co.

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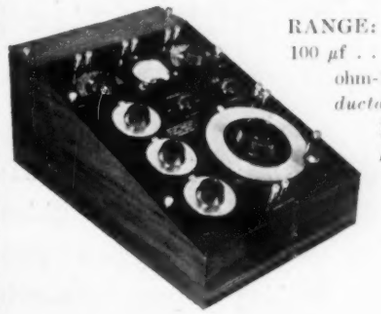

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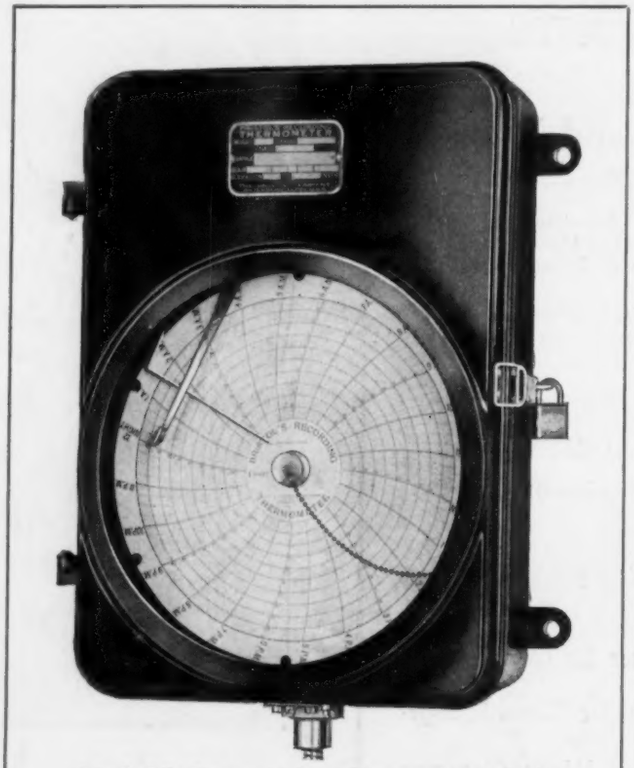

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THIS IMPROVED *liquid filled* thermometer charts accurately the temperatures to which the sensitive bulb is subjected. Neither a long length of connecting tubing nor disturbing temperature conditions along the tubing can impair its precision performance.

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